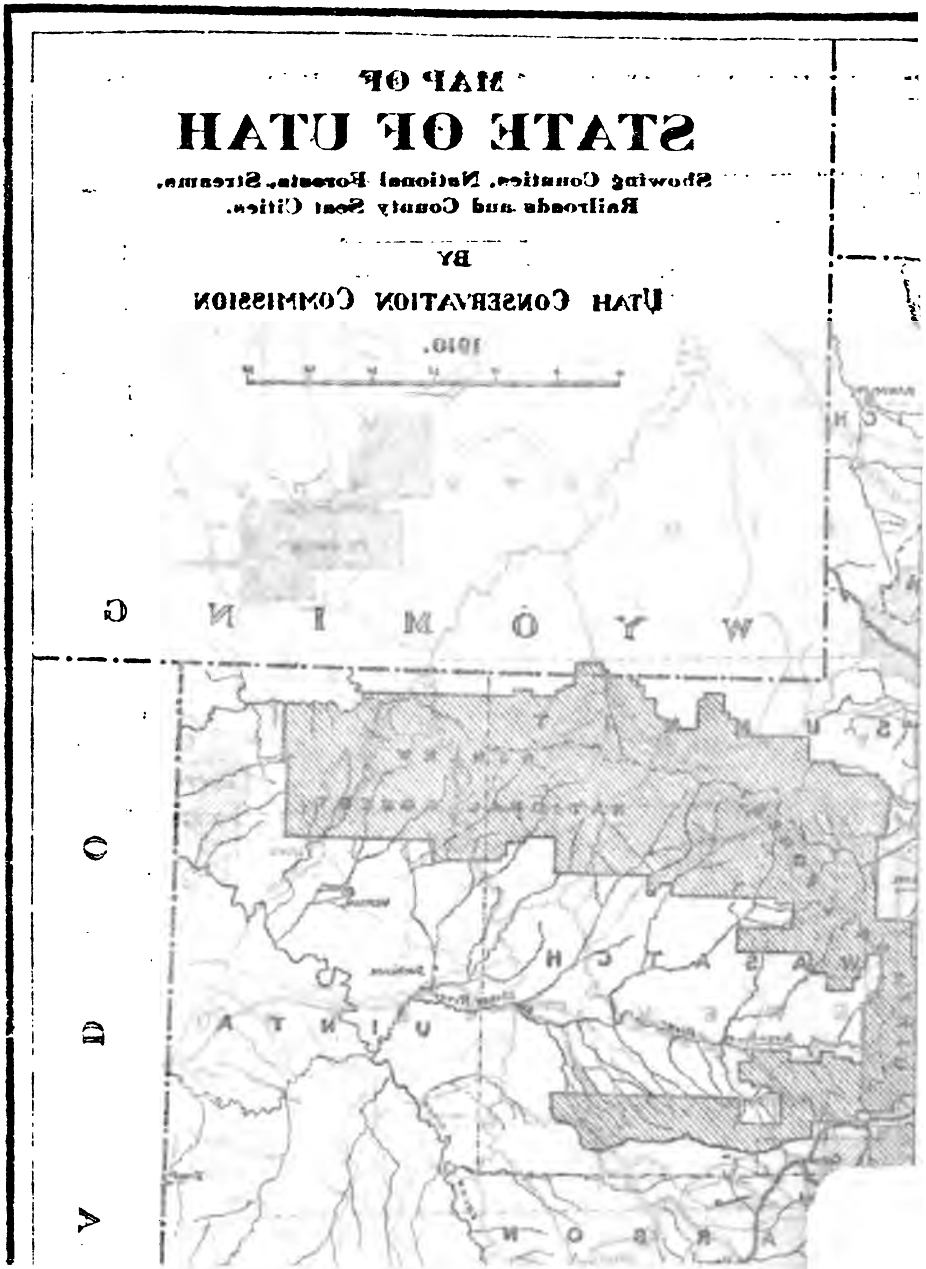
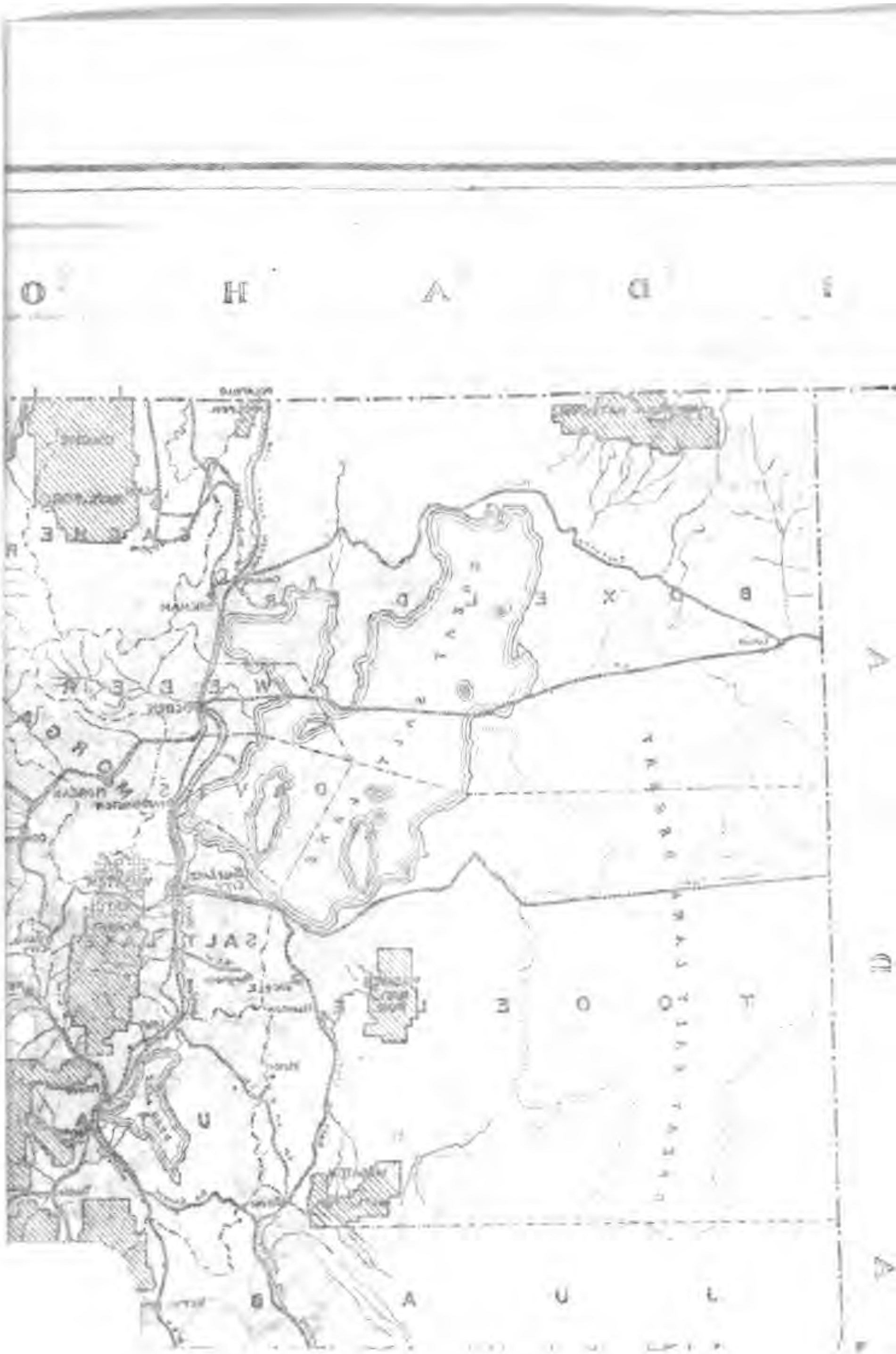
First Biennial Report

of the

Utah Conservation Commission


MAP OF
STATE OF UTAH
Showing Counties, National Forests, Streams, Railroads and County Seat Cities.
BY
UTAH CONSERVATION COMMISSION
1910.
WYOMING



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UTAH CONSERVATION COMMISSION

1913

SALT LAKE CITY
UTAH

THE ARROW PRESS
Tribune-Reporter Printing Co.
Salt Lake, Utah
1913

Word of Governor Spry

THE wanton waste of our national resources---the improvident drafts on Nature's storehouse, carried on for these many years by the voracious few and countenanced by the thoughtless many---have at last been forcibly brought to the attention of the American people. Condemnation of this waste has found utterance in every section of the country, and scientific remedial measures are being developed in the great National and State Conservation movements inaugurated during the administration of President Roosevelt.

Rich with the gifts of Nature beyond any other section of the country, Utah should be deeply interested in these movements. Fortunately the ruthless hand of the public resource pillager has rested lightly on our State, and restoration is less a problem than conservation.

The Utah State Conservation Commission is engaged in the task of making an inventory of the state's resources, developed and unde-

veloped, and issuing a report which shall establish a sure and substantial foundation for economically drawing on our natural resources for the needs of the present generation, and husbanding them for the needs of the future generations. The labor such a report involves is great, and I earnestly urge all State, County and City Officials, and the people of Utah generally, to co-operate with and support these public spirited gentlemen in the work which they have undertaken.

Submitted

To His Excellency, William Spry,

Governor of Utah.

Sir: The first biennial report of the Utah Conservation Commission is hereby respectfully submitted. A preliminary report was submitted in 1909 and the demand for this report has exhausted the supply. We have therefore included in this report some material from that document—revised and brought up to date. We have earnestly attempted in our work to discover and make record of the resources of the commonwealth, and while we cheerfully concede many imperfections, we express the hope that the future work of the Commission may result in more perfect knowledge of our resources and that our people may derive the largest possible measure of utility from them.

We desire to express our appreciation to and acknowledge the assistance of various Government and State officials in the work of compiling data.

We have the honor to remain,

THE UTAH CONSERVATION COMMISSION.

UTAH STATE CONSERVATION COMMISSION.

GOVERNOR WILLIAM SPRY, Chairman.

O. J. SALISBURY, Vice Chairman,
Felt Building, Salt Lake.

LEWIS A. MERRILL, Secretary,
Boston Building, Salt Lake.

JOHN A. WIDTSOE, Agricultural College, Logan.

THOMAS L. ALLEN, Coalville.

GEORGE AUSTIN, Salt Lake.

H. T. HAINES, Salt Lake.

J. E. PETTIT, Salt Lake.

B. B. MANN, Clerk, Salt Lake.

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Charter One Hundred and Three

The following law, enacted by the Legislature of Utah in 1909, and amended in 1911, is the charter under which the Utah Conservation Commission operates:

Section One. That a commission to be known as the Utah State Conservation Commission is hereby created, to consist of not less than three members, citizens of the State of Utah over the age of 21 years.

Section Two. That the Governor of the State of Utah shall be ex officio a member and chairman of said Commission, which shall serve for a term of four years without compensation.

Section Three. Duties of Commission. It shall be the duty of said Commission to investigate and ascertain the natural resources of the State, to adopt and carry out such policies and measures as will prevent waste of the same, and to co-operate with the National Conservation Commission, the Conservation Commissions of other States, with departments, bureaus and officers of the United States, and with departments, commissions and officers of the State of Utah in any way that shall have for its objects the investigation and conservation of the natural resources of the State of Utah. And it shall also (be) the duty of the Commission to enquire whether the waters of any stream or other source of water supply situated within this State can be wholly utilized for irrigation on lands lying under that source of water supply, and if not, whether such waters can be used for purposes other than irrigation, which are more beneficial to the public good.

The Commission shall also enquire whether the waters of any stream or other source of water supply, if utilized for power purposes, would interfere with the storage of water for purposes more beneficial to the public good.

A report of the findings of the Commission in such matters shall be made to the State Engineer.

The Act further provides that the Commission is to:

1. **Collect and publish statistics and data relative to the natural resources of the State of Utah.**

2. To place before the legislative and executive departments of the United States, including the National Reclamation Service, data and facts showing the great value of the arid lands in Utah when subjected to irrigation, and facts and information for the guidance of the legislative and executive departments of the United States in establishing dams, reservoirs and irrigation systems for the reclamation of arid land in the State of Utah.

3. To aid the Forestry Department of the United States in the protection of the timber lands and water sheds in the State of Utah, and also to procure equitable privileges to the users of national forest reserves in the State of Utah.

"WASTE NOT, WANT NOT."

The purpose of the Utah Conservation Commission, in the present paper, is to present a report of so much of the work as has been accomplished along untried ways, and to lay the foundation for more complete and more helpful papers later on.

It has been the aim of the Commission to find exactly what are the natural resources of Utah in soil, in minerals, in water and in wood; to find if either of these resources has been wasted by the people, either through lack of knowing how best to conserve them, or for any other reason; and to point out how much more rich and fortunate the people would be if the waste were eliminated, and all the resources employed.

Both in this report and in the future activities of the Commission it is the purpose to suggest the reforms that should be adopted, the laws that should be enacted by the Legislature of the State; to more actively and effectively co-operate with such agencies as have been established by the State of Utah, looking to the conserving and utilizing of all the resources of the State.

It is also the purpose of the Commission to work in perfect harmony and large effectiveness with the National Conservation Commission, and with the Commissioners of other States—to the end that the general cause may be promoted in the country at large, as well as in the State of Utah.

For it is the conviction of this Commission that the old adage is true, and that if the people waste nothing of their resources, they will never in the future want for anything.

Utah Conservation Commission

OUTLINE OF THE BEGINNING AND PROGRESS OF THE NATIONAL CONSERVATION POLICY.

Comparison of the natural resources of the present with the natural resources of fifty years ago is so significant and the rate of waste so great that it strikes at the very foundation of national prosperity and threatens it with destruction.

The realization of these conditions and the importance of this question brought about what has become known as the Conference of Governors, called by President Roosevelt at Washington, May 13 to 15, 1908, and attended by the Governors of the States and Territories, as well as by the Senators and Representatives of the Sixtieth Congress, and by a large number of representatives of various scientific and economic associations and organizations.

FIRST MEETING TO CONSIDER CONSERVATION.

This conference was the first step taken toward the recognition of the urgent necessity for a national conservation policy; and so vital is the importance of this movement to conserve the natural resources of our country that for the first time in the history of our government the chief executive officers of the States separately, and of the States together forming the nation, were assembled to consider it.

The result, in brief, of the Conference of Governors, was the arousing throughout the country of thought and general interest in the need for proper use of our natural resources, and the recommendation by this Conference for the appointment by each State of a Commission on the Conservation of Natural Resources to co-operate with each other and with any similar commission of the Federal Government; also, a recommendation for the creation of a National Conservation Commission.

Acting on the suggestions of the Conference of Governors, on June 8, 1908, President Roosevelt appointed a National Conservation Commission, with Gifford Pinchot as chairman.

JOINT CONFERENCE AT WASHINGTON.

On December 1-7, 1908, at Washington, a Joint Conference on Conservation between the Governors of States, the State and National Commissions and representatives of national associations was held, the object being to confer on an inventory of the national resources, prepared by the National Conservation Commission, and to discuss means and methods for promoting the work of conservation.

At this conference the report of the committee on organization was approved, one of the principal points of this report provided for the appointment of a joint committee on conservation with Gifford Pinchot as chairman, and Thomas R. Shipp as secretary, which should act as a medium of co-operation or clearing house through which the various State Conservation Commissions and conservation organizations could be kept in touch, each with the other and with the National Conservation Commission, and to act in a capacity of suggesting plans for operation of the various State Commissions.

The first National Conservation Congress was held at Seattle, August, 1909, at which a permanent organization was affected under the National Conservation Congress.

WORK OF THE UTAH CONSERVATION COMMISSION.

Pursuant to an act passed by the Utah Legislature and approved March 22, 1909, the Utah Conservation Commission was duly appointed by the Governor and held its first meeting May 26, 1909. The Commission consisted of Governor Wm. Spry, O. J. Salisbury, John A. Widtsoe, Joseph F. Merrill, Leroy Armstrong, Thos. L. Allen and Geo.

Austin. This Commission organized with Governor Spry, chairman; O. J. Salisbury, vice-chairman, and Jos. F. Merrill, secretary. During 1909 eight formal meetings were held, at which a permanent organization was effected, work outlined and assigned to various committees, and considerable progress made in making an inventory of the resources of the State.

During this year five delegates were appointed to represent the Commission at the National Irrigation Congress at Spokane, Wash. A preliminary report was published during the year.

During 1910 the Commission held ten meetings and succeeded in still further perfecting plans of organization and arranging for a systematic study and survey of the State's resources.

Two members represented the Commission at a meeting of the National Conference on Conservation during January and reported that Utah had been highly complimented at the Washington meeting for being the first State to present a conservation report. During this year plans for the publication of a resource map of the State were inaugurated. Because of his removal from the State the resignation of Mr. Leroy Armstrong was accepted on March 23, 1910.

During 1911 the Commission held five meetings, prepared and distributed a large resource map, considered and approved plans for a soil survey in co-operation with the Utah Experiment Station, considered measures in relation to the conserving of coal in the mining thereof and also gave considerable attention to laws concerning applications for water rights and power rights.

During 1912 nine regular meetings of the Commission were held. Dr. Jos. F. Merrill, secretary of the Commission, tendered his resignation in March, and the Governor appointed the following new members, viz: H. T. Haines, State Statistician; J. E. Petit, State Coal Mine Inspector, and Prof. Lewis A. Merrill. At the June meeting Prof.

Lewis A. Merrill was elected secretary and the following committee assignments made:

COMMITTEES.

National Forests—O. J. Salisbury and L. A. Merrill.

Agricultural Resources—Dr. J. A. Widtsoe and L. A. Merrill.

Water Power and Irrigation—Thos. L. Allen and Geo. Austin.

Mineral Resources—H. T. Haines and J. E. Petit.

During this year the Commission made an investigation regarding the feasibility of conveying water from the Provo and Weber rivers onto the land in Tooele county, also the feasibility of conveying water from the Strawberry project onto the lands in northern Juab county, and from the Piute project through Levan Canyon onto the lands of southern Juab county.

Questions regarding the utilization of slack coal in providing electric power, better use of irrigation water, co-operative work with the Utah Experiment Station and with the Hydrographic Survey division of the United States Government, occupied the attention of the Commission. During the year a delegate was sent to represent the Commission at a meeting of the International Dry Farming Congress at Lethbridge, Canada.

RECOMMENDATIONS.

The Utah Conservation Commission has put itself in touch with the existing organizations employed in the study of Utah's natural resources. A large amount of available information is at hand, and the State is to be congratulated on the efficiency with which these organizations are carrying on their work. The organizations referred to are the State Agricultural Experiment Station, the State Game and Food Commission, the State Board of Horticulture, the

State Board of Sheep Commissioners and the offices of the State Statistician and the State Coal Mine Inspector—all of which are well organized and regarded everywhere, not only within but without the State, as efficiently conducted bureaus.

The permanent welfare of the State demands that its natural resources be conserved by proper use. To this end the State can do much by legislation and by example. The first duty of this Commission is to gather and distribute a knowledge of our natural resources and of the means necessary to insure their use and conservation, to impress all the people with the great importance of these resources and their proper utilization.

This Commission should, in our opinion, have an accurate and definite knowledge regarding the various projects and enterprises throughout the State. It should be in a position to give safe advice to investors and to properly safeguard the interests of those who would make their homes here. There is no phase of our industrial life that means so much for the development of our State's resources as the inauguration and development of irrigation projects. There is, however, always an opportunity here for investors to be easily mislead. It seems to this Commission that it is the duty of the State to safeguard these projects so that would-be investors may be protected and at the same time that the interest of legitimate promoters shall be guarded.

Too, there are many sections of this State adapted to dry farming, and there are others where with present known methods dry farming does not succeed. We believe it to be to the interest of the State in its permanent development, that a survey of all projects be undertaken, analyses of the soil and water made, and that all development enterprises be given such measure of firm, but thoroughly just and practical supervision, as will serve to give the stamp of approval of the State to meritorious projects and prevent loss and disappointment on unworthy ones.

We believe, too, that with the completion of the Panama Canal there will be a great influx of homeseekers into the State. It would seem to us most desirable if a very careful study of the State's resources and possibilities could now be made so that those seeking homes might be directed to localities where they may become permanently established. An exhaustive report covering this matter should be undertaken at once, and be ready for distribution at the World's Panama Exposition at San Francisco in 1915.

In brief the Commission recommends:

1. The continuance of the Commission with enlarged powers and with an adequate annual appropriation ($6,000 for the biennium) to meet the expenses connected with the propagation of work which is normally the function of such an organization.

2. That a complete survey of the lands and waters of the State be made in co-operation with the State Agricultural Experiment Station, and that complete co-operation with the various State Boards be had with a view of compiling data valuable for the homeseeker.

3. The Commission particularly recommends a study of the various irrigation and dry-farming projects, together with a study of the feasibility of profitably draining our swamp and alkali lands.

4. It is recommended that the Commission's work in disseminating information regarding the proper use of water to prevent over-irrigation, the employment of more scientific methods on our arid lands, better methods of mining to prevent waste in coal mining particularly, and the preparation of reports and maps showing the resources and possibilities of the State, be continued.

5. We believe that the office of the Commission should be made a scientific bureau of information, so that those seeking investments may find here a conservative an dsafe guidance. This policy, necessary for the ultimate protection of the interests of the State, is in accord with the principles adopted by the National Conservation Commission.

6. Finally, this Commission proposes to deal with the two important factors in the question of conservation—the physical and the vital. The former relates to the protecting of our land, our forests, our minerals, our waters, our sunlight, and our fresh air; the latter to the prevention of diseases, to the heal th and to the prolongation of life.

RESOURCE MAP OF THE STATE OF UTAH.

The beautiful new Resource Map of Utah, prepared by the State Conservation Commission is now ready for distribution. This is by far the most complete and up-to-date map of the State that has ever been prepared. It has been drawn to a large scale—a sixth of an inch to the mile, mounted on cloth with rollers top and bottom, ready to hang. It so large that every section of surveyed land in the State is shown by a square a sixth of an inch to the side. All of the U. S. and State records that could furnish information were consulted in collecting data for the map. It has been so carefully drawn that it shows the U. S. survey lines, including "offsets" and the correct location of the cities, towns, county boundary lines, railroads, principal and secondary wagon roads, canals, reservoirs, lakes, streams, land boundary districts, experiment stations, coal beds, outcrops, iron ore deposits, hydrocarbon veins, forest reserves, mining districts, mountains and peaks, valleys, electric power plants, etc. The forest reserves are colored green, revealing at a glance their location and extent. With such detail has the map been drawn that even the location of isolated ranches is given.

A table has been carefully prepared of the cities and towns, giving their location, population, elevation and railroad, telegraph, telephone, express and postal service. The map shows at once where all the surveyed and unsurveyed lands are, and together with a report that will be published later, the character and ownership—public and private—of the land. Practically everything that a map can show is shown by this new map. It will be a necessity for the home seeker, the surveyor and the person who wants accurate, trustworthy information about the geography and natural resources of the State. It should hang upon the walls of every school and library in the State. The Commission will make this map the basis of a series of reports in which will

be published the great quantity of data that has been collected in the preparation of the map.

This will be in accord with the first aim of the Commission, as determined in the early days of its organization, to collect and publish full and reliable information about the natural and undeveloped resources of the State—resources that are so vast and varied as to be astounding even to old-time residents.

This map is being sold at $5.00 per copy, which is considerably less than cost of production, and can be had (while they last) by addressing Col. B. B. Mann, 214 Felt Building, Salt Lake City.

LAND

Agricultural Resources of Utah

INTRODUCTION.

Utah's claim that she must of necessity become one of the great commonwealths of the country rests primarily upon her surpassingly great agricultural resources. Utah is a young State, scarcely yet conscious of her boundless natural resources. Her soils have scarcely been touched; the limits of production on these soils are not half understood and the crops which, commercially, will make of Utah one of the great agricultural States of the Union are just beginning to be cultivated. The period of pioneer life during which were laid secure foundations for membership in the sisterhood of States, required the founders of the State to confine themselves largely to the more elementary practices of agriculture. This preliminary period in the State's growth has now been passed, and Utah is entering upon its period of great agricultural development.

AREA.

Utah covers an area of 54,300,000 acres. Of these, about twenty million consists of mountains and lakes, and approximately twelve million acres are coal, salt and similar lands. The remaining twenty-two millions are all subject to agricultural cultivation. Of this vast agricultural area less than one-tenth is cultivated at the present time. This fact, alone, shows the great possibility for agricultural development.

SOILS.

The soils of Utah are intimately connected with the early geological history of the West. The western half of the State lies within the Great Basin. Most of the eastern half forms the high plateaus of Utah and partakes very

much of the character of the soils of northern Arizona and eastern Colorado. The northeastern corner of the State is filled with high mountains, covered with trees and nutritious grasses. In the Great Basin section of the State, the soils have been formed by the action of the prehistoric Lake Bonneville, which formerly covered the whole of what is now known as the Great Basin. The washings from the mountains were carried down into the lake by the rivers and distributed over the lake bottom to form the soils of the present day. These soils are of unusual depth and fertility. Their lower layers, to a depth of forty and fifty feet are almost as fertile as the surface soils. The soils covering the eastern half of the State, known as the high plateau soils, were formed in early geological days when a shallow ocean covered that portion of the State. From the manner of their formation they are also of remarkable depth and fertility. Like the Great Basin soils, their subsoils are practically as fertile as the top soils. In the mountainous regions the small valleys are filled with washings from the mountains, forming soils of high fertility. The fact that the rainfall is not sufficient to drain through the soils to wash out the fertility, has conserved for untold ages the store of plant food. All in all, Utah soils are of unsurpassed fertility. Every landowner within the State owns virtually not one, but several farms, because of the equal fertility of the layers of the soils to very great depths which is drawn upon by the deep-going plant roots.

However, even with this high fertility, the conservation of Utah soils needs to be carefully considered. Improper methods of irrigation and continuous cropping with exhaustive crops will tend to diminish the native fertility of the soil. On the other hand, scientific investigation has already demonstrated that by proper methods of tillage the fertility of Utah soils may be maintained indefinitely so that the time need never come when we shall have to deal with the question of exhausted soils which is now the most vital question in Europe and many of the older sections of the

country. The conservation movement can probably do no greater service to this State than to make possible an extensive study of the present soil resources of the State of Utah and a determination of the methods whereby the fertility of the soil may be conserved indefinitely.

Recently the Utah Experiment Station in co-operation with this Commission has prepared two bulletins giving analyses of soils from various sections of the State. These bulletins are appended to and made a part of this report.

UNDERGROUND WATER SUPPLY.

Since the river waters, if fully conserved, will suffice to irrigate at the most only a fifth of the lands of this State, it naturally follows that the question of securing more water for irrigation purposes is a vital one among the people of the State. Recent investigation has indicated that the great valleys of the State are underlaid by water. The Federal government has made some study of this question and has succeeded in locating large bodies of underground water. The State administration, likewise, has spent time, money and effort upon this subject. To the joy of the people the State has already succeeded in reaching subterranean water that may be used for culinary and irrigation purposes in some of the most desert places of the State. The probabilities are that in the very near future artesian wells and the pumping of water from deep wells will be important factors in the reclamation of Utah. Just what proportion of the lands of the State will be irrigated in this manner is difficult to foretell, but certainly it will be many hundreds of thousands of acres.

USE OF THE NATURAL PRECIPITATION.

The water resources of Utah cannot well be dismissed without considering also the recent development in dry farming, which has taught that the natural precipitation of the State, if properly conserved in the soil, may be made to produce profitable crops without irrigation. When it is

considered that twelve inches of water, properly stored in the soil, are sufficient to produce most of the ordinary crops, it follows that practically the whole of the State of Utah may be made agriculturally profitable. If enough rainfall does not fall in one season, it has been learned that the rainfall of two seasons may be stored in the soil, and in that way crops may be obtained every other year. Even this is a great deal better than to leave the land, as it is at the present time, lying idly as great deserts covered with useless plants. To teach the people the possibility of reclaiming the arid lands of the State without irrigation is not the least important work before the Conservation Commission.

THE WASTE OF WATER.

While water is the critical factor in Utah agriculture, yet it must be confessed that there is a great waste of water in our State. As in the other irrigated States, farmers have come to believe that the more water they apply to their soils the surer are they of a large crop. The recent experiments carried on by the Utah Station as well as by the Federal government has shown the fallacy of this idea, yet the new truth has not sunk deep into the consciousness of the farming population. It may be necessary to secure legislative enactment to control the use of water in order to prevent such waste. No man has the right to use more water than is really necessary, for, as explained above, it will ultimately result in the bringing up of alkali somewhere in the State in addition to depriving some other piece of land from the water that is thus wasted.

CLASSES OF UTAH FARMING.

In accordance with the nature of the lands and the precipitation of the State the agriculture of Utah falls into three distinct classes. First, irrigation farming, which is confined to those portions of the State where artificial application of water has been made possible; second, dry

farming which covers those portions of the State where the rainfall is sufficient to produce crops without irrigation and where there is no irrigation water available; and, third, the range stock industry which represents the utilization of the vegetation growing on the mountains where the nature of the land forbids agricultural operations, and the very desert portions of the State where the rainfall is not sufficient to produce crops without irrigation. These branches of Utah agriculture are all in a stage of transition, brought about by the recent rapid development of the State and the new knowledge which has come to the West concerning its agricultural practices.

IRRIGATION FARMING.

The irrigated area of the State is at the present time only about one million acres, with a possible maximum of ten million of acres, when all the waters in the State shall be held back in canals and reservoirs and used in the best way. There are about 2,200 irrigated farms in the State of Utah, averaging 45.5 acres each. According to the Government reports the amount of water used per acre is about 4.35 acre-feet. The crops grown on the irrigated lands at the present time are in the main, wheat, with other grains, and lucern, and of the more intensive crops—potatoes, sugar beets, small fruits, apples, peaches and other fruits of that nature and garden truck. The income per acre varies with the crop grown, the care given the land and other local conditions. The personal factor is the main one in considering the profitableness of farming on the irrigated lands of Utah. The farmer himself is the first consideration in determining the the success or failure of any farm. When the right crops are chosen, and the right care given the soils and plants, yields representing $100 to $1,000 per acre are not uncommon.

It may be noted that these irrigated farms of the State should be cut up into smaller farms. There has been in the past a desire on the part of the people to maintain large irrigated farms. There are thousands of farms in the State

Alfalfa Field at Perry, Box Elder County. Yield Six Tons per Acre.

from eighty to two hundred acres. No man can do full justice to such a tract of irrigated land. We are coming more clearly to understand that from five to fifteen acres are quite sufficient to maintain a family in comfort and to provide against old age, providing, of course, that the more intensive methods of farming are used. This is one of the directions in which the conservation movement can be of tremendous value to the development of Utah. The people should be taught the best methods of cultivation and the best crops in order to obtain the maximum returns for the outlay of time, money and energy. It should be shown that it is more satisfactory in every way for a man to do the best kind of work on a small farm than to do slipshod work on a large farm. If the people could be made to understand this, many more thousands of families could be maintained on the present irrigated section of the State.

DRY FARMING.

The possible dry farm area of Utah is practically all that which is not occupied by mountains or under irrigation canals, with the exception, perhaps, of some of the more desert districts where the rainfall is under ten inches. It would appear at the present time that wherever the rainfall is above ten inches dry farming may be made to succeed. While dry farming has been practiced in Utah for upwards of half a century—in fact, Utah is the pioneer dry farming State—yet it is only in recent years that dry farming has taken hold of the general public. At the present time, dry farming is practiced in some degree in all the farming districts of the State. It is difficult to estimate just how many acres are being used for dry farm purposes, since the industry is growing so rapidly, but the area runs into hundreds of thousands of acres and may at the present time approach one million acres. The yields are very good. The chief dry farm crop is wheat, the average yield of which for the State is about twenty bushels to the acre. Barley, oats and rye are also successful dry farm crops. During recent

years, potatoes have also been found to do well without irrigation in districts that were formerly supposed to be hopeless deserts. Lucern does well on the dry farms, especially for seed production. Other fodder plants have been tested and almost without exception have been found to yield well. As a general rule it has been necessary to grow any new crop for some seasons under dry farm conditions before it has become adapted to arid conditions. However, plants readily adapt themselves to arid conditions and by a little experimentation successful results follow. The introduction of new plants and the adaptation of old plants to arid conditions are leading subjects in the reclamation of the dry lands of the State, which may well be fostered by the conservation movement.

It has been found also that crops grown on dry farms are much more nutritious than are those grown in humid climates. The nutritive value of wheat, for instance, is from one-tenth to one-fourth higher when grown on dry farms, so that one bushel of wheat represents a larger amount of feeding material. Potatoes and other crops, likewise, are improved as they are grown with a minimum of water. This fact should not be overlooked by the irrigation farmer who also desires to produce the highest quality of crops. In fact, the dry farmers of the West have it in their power to compete most successfully with the great wheat growing districts because of the superior quality of the grain grown under arid climates. Fruit may be grown in small quantities on dry farms. It is somewhat smaller than that produced on the irrigated farms, but it is of very much finer flavor and quality.

No man can foretell at the present time where the end with respect to dry farming, will be. Of one thing we are certain, that within the State of Utah alone there are several empires now lying idle as deserts that will be reclaimed by the methods of dry farming. New discoveries by the experiment stations are showing how crop failures may be avoided. In fact, deep fall plowing for the conservation

of the soil moisture, the fallowing of the land every other year, the planting of a comparatively small quantity of seed, keeping the plants tolerably far apart and the continuous cultivation of the top soil—all combine to make crop failures on dry farms an almost unheard-of thing. The discovery that the underground waters may be reached on our Utah deserts makes possible the establishment of homes on our deserts. There is no question that millions of people will obtain their living from the now barren deserts covering the larger portion of our State. Nor is it to be forgotten that the present crop yields are small in comparison with those that may be obtained as better methods of cultivation are discovered and applied. At the present time twenty bushels of wheat per acre is a fair dry farm average; but the various experiments carried on by the State indicate that it may be possible to secure from thirty to forty bushels under more improved methods of tillage. In order to facilitate the reclamation of the Utah deserts, the State Legislature authorized some years ago the establishment of six small experimental farms which have been of great value in showing the farmers in what localities of the State dry farming may be practiced and in teaching the most profitable methods to follow.

RANGE INDUSTRY.

The third branch of agriculture in Utah is the range industry. In former days sheep and cattle were allowed to graze in the mountains and on the deserts to such a degree that many of the native grasses were thereby destroyed. In fact, there are millions of acres of land in the State today which, when the pioneers arrived, were covered with luxuriant grasses, but which now are barren wastes because of the overstocking of livestock upon them. With the recent activity of the Forest Service, the formation of National forests and the more general private ownership of the lands of the State, these lands have recovered in a measure their past condition. The large area of the State which never can

be subjected to irrigation or dry farming makes it certain that the range industry will always be a leading branch of agricultural activity in Utah. There are problems awaiting solution for the development of this branch of agriculture also. For instance, on the deserts which cannot profitably be used for dry farming, grasses may be introduced which will appear perennially and furnish at least a scanty herbage for the range sheep during the winter season. Likewise, in the mountains there is a possibility of introducing new grasses and of spreading more generally the native grasses, in order to make the feeding possibilities of the mountain valleys greater than they are today. On the ranges are found great numbers of sheep, an abundance of cattle and large numbers of horses and mules. The possibilities of the ranges are yet poorly understood. The rough, haphazard methods of the past are going out of vogue and the new and more systematic methods are just being adopted. Although the National forests are being established and great regulation is insisted upon, yet there will be no reduction in the value of the range industry. On the contrary, as better methods for the care of mountains and deserts are developed, more than likely the range industry will become more valuable than ever before. The Conservation Commission can take a leading part in advancing this branch of Utah's resources.

GRAINS AND SEEDS.

The grains and seeds grown in Utah are chiefly wheat, oats, rye, barley, corn, together with lucern seed. As already remarked, wheat of extremely high quality is now largely grown on the dry farms. Oats, rye and barley are still grown chiefly on the irrigated farms. Corn has been found to be the best of all crops for desert conditions and there is an opportunity for showing the way to greater prosperity by increasing the acreage of corn and in teaching farmers to feed this corn to livestock for fattening purposes. Our lucern seed is famous the world over and may be made

Wheat Grown Without Irrigation on Provo Bench, Utah County. Yield 44 Bushels per Acre.

even a more profitable source of revenue than it is at the present time. The following table shows the acreage and the total yields of crops in the State of Utah:

ESTIMATED ACREAGE AND PRODUCTION OF CROPS IN UTAH FOR THE YEAR 1910.

	Acres.	Total Yield in Bushels.	Value.
Wheat	255,000	5,708,000	$4,795,000
Oats	58,000	2,494,000	1,197,000
Barley	13,000	468,000	281,000
Corn	13,000	394,000	331,000
Rye	3,000	56,000	38,000

WHEAT.

It is perhaps not generally realized that one of the largest undeveloped wheat areas in the United States centers about Salt Lake City. In Utah alone there are probably 15,000,000 acres of land now unused, the soil and natural conditions of which make wheat a natural crop. At the present time there are but 255,000 acres in wheat, with a yield of 5,708,000 bushels and a valuation of $4,795,000.00.

Only a few years ago spring wheats were very largely grown and, as a matter of fact, predominated. Now, however, winter wheat occupies 155,000 acres of the 255,000 acres under cultivation in wheat. The soil for wheat is uniformly excellent. It is, as a rule, very deep and is composed of sand and silt or detritus, with the two latter predominating. Heavy, sticky clay soils are the rare exception. It is easily worked, is a loose, warm loam of fine texture and well compacted, possessing a sufficient amount of nitrogen of high availability, rich in the needed constitutents, retentive of moisture and homogenous to depths unheard of in eastern and central portions of the continent. It is an almost ideal combination for wheat farming. The rainfall varies in different localities from 7 to 25 inches per annum, and it is important to state that the bulk of it comes in the cool

seasons of winter and spring, a fact which makes it possible to conserve in the soil a very large portion of the moisture.

It is true that we have in the past grown too many varieties of wheat, practically all of them the soft white varieties characterized by a low gluten content. Our commonest wheat, Gold Coin, is actually at the bottom of the list. Both factors have given a low value to the wheat of the intermountain west, as flour for breadmaking purposes must be of a uniform grade and of high gluten content. There has been too strong a tendency among us in the past to bring to the market grain that we can only describe as "just wheat." Consequently, Utah flour is discriminated against by bakers, not only abroad but at home, except in those cases where it is known to be milled from our best grade of hard wheat, in which case it is eagerly sought for. Now, it is just as important to stick to one or two straight varieties in the raising of wheat as of fruit, for bakers universally make a sharp distinction between the flours made from soft or ungraded wheat and those made from hard grains. The hard wheat contains the most protein, and the flour made from them will make up into a greater number of loaves per pound of flour. This preference, of course, governs the market for wheat, which is affected by only one other large commercial demand, that is, the macaroni manufacturers, whose preference is also for the super-hard grains with high gluten contents. One great necessity is, therefore, that our farmers should center upon a hard wheat that will meet the demand of the market. It is a demonstrated fact that with care in seed selection and the elimination of all but one variety, namely, the Turkey Red winter wheat, the superiority of which has been proven by exhaustive milling and laboratory tests conducted by the Utah Experiment Station, Utah can become one of the finest wheat growing countries in the world, as well as one of the most prolific, far surpassing the Pacific coast in the quality of its products, and at least equalling the Dakotas and Kansas.

One of the greatest needs of the wheat industry is to bring the farmers of the State to a realization of the fact that they must abandon the growing of wheat on irrigated lands. Such grain contains too little protein and too much moisture and cannot compete with that grown under dry-farm conditions. We should remember that irrigation is a specialized kind of farming, suitable for the growing of such crops as fruits and the small vegetables, and that irrigation water is too valuable to waste in the cultivation of cereals, even if the irrigationists were able to produce grains of as fine a quality.

BARLEY.

Barley has not been extensively grown in this State up to date, and as will be seen by the table, only 13,000 acres were devoted in 1910 to the production of this crop. There was a yield of 468,000 bushels, valued at $281,000. However, barley has been found to be pre-eminently adapted to sections of limited rainfall since it requires less water than does wheat or oats for its production, and also from the further fact that its maturing period is much less than for oats or spring wheat. There is always a good strong demand for barley both for food for domestic animals and for malting purposes. For these reasons, barley will be more extensively grown on dry lands of the State. Recently some fall varieties have been developed in the State and now we have what is known as the "Utah Winter Barley," far exceeding in yield any of the spring varieties. We believe that when this fall variety becomes acclimated even better results will be secured than heretofore. The results so far secured, however, would justify a more extended use and growth of barley on our available land.

OATS.

It must be confessed that in the production of oats Utah does not possess any exceptional advantages. During 1910 there were but 58,000 acres devoted to the culture of this

crop with a yield of 2,494,000 bushels, valued at $1,197,000.00. The fact that this crop does not play a more important part in the agriculture of the State is due to the conditions which made it impossible for a long while to produce the crop on dry land. It was considered to be primarily a crop adapted to irrigation, and since irrigated land is, as a rule, too valuable for the production of cereals, oats has not played a very important part. However, varieties of oats adapted to production on dry land have become available through the efforts of the Utah Experiment Station. In San Juan county on dry land, fairly good yields have been obtained, one variety giving an average yield through several years of 37.12 bushels and another variety giving an average yield of 33 bushels per acre. At Nephi, on the dry farm, yields as high as 50 bushels per acre have been reported. Another variety gave a yield of 48.8 bushels per acre. The average yield of the Boswell oats, a fall variety, has been better than 40 bushels per acre under dry farm conditions. There is no doubt but that with increased knowledge regarding the production of oats on arid lands, the output of this crop will be materially increased within the next few years.

SUGAR BEETS.

The sugar beet industry which was born in this State a little more than 20 years ago has grown to very great proportions and is an important source of revenue for the farmers of the State. There are in the State five sugar factories which annually consume 455,064 tons of sugar beets and return to the farmers $2,047,788. The sugar beets grown in Utah contain an unusually high percentage of sugar, so that the business is a profitable one for the factory. It is interesting in this connection to note that Utah produces 14.52 tons of sugar beets per acre as compared with 10.63 tons for California and 10.33 tons for Colorado.

There is yet considerable to be done in the matter of development of even better methods than we have at the present time for the production of beets and also the proper

use of the by-products of sugar factories. It may be said in this connection that the sugar factories of the State have been splendid factors in the dissemination of correct methods of agriculture among the people.

POTATOES.

Utah is favored in having both climatic and soil conditions favorable to potato production. Our soils are rich, deep and mellow. The moisture in the soils can be easily controlled through irrigation methods. The percentage of days of sunshine so necessary in potato production is very large.

These factors all favor not only a large yield per acre of good marketable tubers, but if correct methods are followed, good quality as well. It is not enough that a large number of bushels of potatoes be grown per acre, but it is equally as important, if not more so, that the quality be of the best. In 1910 Utah produced 2,432,000 bushels of potatoes on 16,000 acres of land, or an average of 152 bushels per acre. Most of the potatoes in the State are grown in Salt Lake, Utah, Davis, Sevier, Weber, Morgan, Cache, Wasatch, Emery, San Pete and Boxelder Counties. This crop should receive more attention from the irrigation farmers of Utah than is at present given to it. This Commssion believes that the potato is destined to become one of our leading crops and is bound to take its place in our permanent rotation for the land under the irrigation canals. We have the fertile soil, good climate, moisture control and are fairly near to good markets, so that with the good quality which our properly grown potatoes have, the industry in Utah ought to grow and prosper.

FORAGE CROPS.

The chief forage crop of Utah is lucern which is grown most extensively on the irrigated farms, though the dry farms are gradually being seeded to lucern. There are large

acres of irrigated lands lying somewhat low that are and should be used primarily for lucern production. The proper use of lucern in stock feeding has not yet been taught fully to the people of this State, nor is it fully understood. Of one thing we are fairly certain: that we shall learn in the near future to make better use of this important crop than we do at the present time. The total production of lucern during the year 1911 was 950,000 tons valued at $8,550,000. Tame hays are also grown in considerable quantity, and wild hay is still a source of forage in this State. The total production of tame hay during the year 1911 was 127,117 tons.

FRUIT GROWING.

Fruit growing has become one of the leading agricultural activities of the State, due to the fact that it is an industry particularly adapted to irrigated lands. Apples, peaches, pears, plums, small fruits, strawberries and garden truck are all produced in considerable quantities. The large mining camps near at hand afford an exceptionally fine market for this product and there is no doubt that in the near future fruit growing will be one of the leading agricultural industries.

The soils and climatic conditions are remarkably well adapted to the production of apples and peaches, and in consequence extensive commercial orchards are being planted. The wonderful yields of fruits on the deep, fertile soil, the high coloring and the delicious flavoring have made possible the high promise that Utah in the near future will rank with the largest horticultural States of the Union. The State, however, is yet in its infancy in horticulural matters and the possibilities along these lines are as yet almost wholly undeveloped.

The extent of the nursery business is shown by the fact that in five counties of the State, more than 500 acres are

A Ten-acre Jonathan Apple Orchard in the Bear River Valley. Two Hundred and Fifty of These Trees Produced $1750 Worth of Marketable Apples. The Owner Refused an Offer of $600 per Acre.

devoted to nurseries. The value of the fruit produced in Utah in 1910 was $1,389,978, distributed as follows:

County.	Commercial Shipments.	Local and Peddlers.	Total.
Cache	$ 8,750	$ 9,000	$ 17,750
Box Elder	498,200	54,500	552,700
Weber	103,000	40,000	143,000
Davis	11,280	20,000	31,280
Salt Lake	......	89,350	89,350
Utah	239,100	242,400	481,500
Grand	15,934	......	15,934
Emery	2,900	5,000	7,900
Morgan	270	2,230	2,500
Rich	......	7,272	7,272
Juab	......	6,500	6,500
Beaver	......	1,500	1,500
Carbon	......	1,000	1,000
Tooele	225	3,375	3,600
Sevier	......	4,130	4,130
Summit	......	812	812
Millard	......	1,550	1,550
Washington	......	15,000	15,000
Iron	......	800	800
Wayne	......	5,100	5,100
San Juan	......	800	800
Grand Total	$879,659	$510,319	$1,389,978

From the best information obtainable there are approximately 40,000 acres devoted to nurseries, orchards, vineyards, small fruits and garden products, with an annual production of practically three and a half million dollars.

LIVESTOCK.

There were 20,795 farms in Utah reporting the number of livestock kept shown by the census of 1910. The livestock of Utah represents an investment of $28,330,215.00. The following table gives the number of cattle, horses, mules, swine

and sheep kept on Utah farms with the valuation on each class of livestock:

	Number.	Value.
Cattle	412,334	$8,948,702
Horses	115,676	9,999,835
Mules	2,277	157,497
Swine	64,286	445,653
Sheep	1,827,180	8,634,725

As will be seen from the table the greatest investment in the livestock industry is in horses, with cattle following and sheep coming third.

That Utah is a livestock State is a demonstrated fact. A good irrigated pasture will maintain from two to three cows through an entire season on one acre of ground. Alfalfa hay, one of the most palatable of forage crops finds a congenial home in the soil and climate of this State. The large acreage of available dry land makes the production of grain a very simple matter, so that with this combination there is no reason why Utah should not excel in the production of livestock. It is universally conceded that the success and permanency of any system of agriculture rests upon the maintenance and increase of the elements in the soil concerned in feeding plants. The elements with which the farmer is most concerned are nitrogen, phosphorus and potassium. These elements are all returned to the soil where forage crops and grains are produced, fed to livestock and the manure returned to the land. There is no doubt whatever but that the man who engages in the livestock business in this State with zeal and business discretion will gain a competence and will have the added satisfaction of handing down to his posterity a farm that is richer and more productive than when he received it.

The freedom of our domestic animals from diseases is a matter of general knowledge. Contagious diseases such as hog cholera, tuberculosis and other diseases common to other sections are practically unknown here. The work of the Conservation Commission in connection with the livestock

industry must necessarily be confined very largely to efforts to increase the number of livestock kept and to encourage farmers to eliminate poor and worthless animals and substitute for them animals of good breeding and desirable characteristics.

DAIRYING.

Dairying is rapidly becoming one of the chief industries of the State. With the establishment of condensaries and centralized plants, and the maintenance of many cheese and butter factories, this industry is assuming proper proportions at least in some sections of the State. In Cache Valley, particularly, is dairying receiving proper emphasis and as a consequence the farmers there are unusually prosperous. Cache Valley, however, offers no better opportunities than are to be found in various other sections of the State for this important industry.

There are at the present time some 80,000 cows kept on Utah farms and the value of butter, cheese and condensed milk annually produced approximates $3,300,000. We have in the State 8 cheese factories, 4 condensed milk factories and 40 creameries. That there is an opportunity for increased dairy production is shown by the fact that while 1,000,000 pounds of cheese are annually produced in the State, 4,000,000 pounds more are annually imported, and that while 5,400,000 pounds of butter are annually manufactured in the State, 2,000,000 pounds more are each year imported. In an irrigated State dairying and horticulture must go together in order that the fertility of the soil may be maintained. This Commission feels, therefore, that practically every portion of the State is particularly adapted because of soil, climatic and transportations facilities to the dairy business, and that there is much yet to be done in eliminating poor cows, introducing better grades and in maintaining a higher degree of excellence in the animals used for dairying purposes.

POULTRY.

The value of poultry and eggs produced in this State, according to the latest census figures is approximately $800,000.00. From an investigation of the markets in some of the larger cities of the State it is probable that at least this much more poultry products are annually imported into the State. Utah undoubtedly offers exceptional advantages for the poultry industry. If we take the trouble to compare the climate of the valleys of Utah with the climate of the great poultry producing regions, we shall find that the Utah poultryman has nothing to concede to Nebraska or Kansas or the poultry section as a whole. Although poultry can be and is grown under a great diversity of climatic conditions, climate is a big factor in the cost of poultry production. Mild winters mean cheap houses, less cost for labor, cheaper feed, because the fowls can have a larger proportion of green feed and an earlier chick season, all of which means a greater egg production when eggs are high, and also a greater profit because produced at a less cost for maintenance. The winters in Utah are milder than those of the regions in question. We have fewer sudden changes and fewer cold winds. Our dryer climate is a decided advantage to both and young stock, making threm much better able to withstand the cold and reducing dangers of disease. Until recently a dry climate has been detrimental to the success of artificial incubation, but recent advances in this art have made it possible to overcome this difficulty. Both Kansas and Nebraska have high-priced lands and labor, but on the whole Utah soil is dryer and better drained, which is a decided advantage. With the advent of the hopper method of feeding and the colony method of housing, the cost of labor may be made a much less significant factor than formerly or than is the case at the present time.

As the State increases in population and wealth the more and more valuable will become her farming lands, which cannot be increased in area, but as each acre increases in value the greater and greater will be the demands made upon

it. This increased production can be possible only by the maintenance of the soil fertility and the production of such farm products as will give a maximum return per acre. As a factor in intensive farming, with a capacity for economic food production, the great American hen stands among our domestic animals without a peer, and because Utah demands her products and affords her excellent advantages for their production, she is destined to occupy a greater place in Utah's new and greater agriculture that is coming.

AGRICULTURAL MANUFACTURES.

The agricultural manufactures of the State are confined very largely to the manufacture of butter, cheese, condensed milk, beet sugar, flour, canned goods, etc. The money values of these factories is shown in the following table:

	Value.
Butter, Cheese and Condensed Milk—Year 1910	$3,300,000.00
Flour and Grist Mill Products—Year 1910	3,130,895.00
Beet Sugar—Year 1910	2,047,788.00
Canned Fruits and Vegetables—Year 1910	1,250,000 00
Pickles and Vinegar—Year 1910	300,000.00

These factories furnish a ready cash market for much of the agricultural product of the State, especially those that are of the most intensive kind. It is rather interesting to note in this connection that the value of the butter, cheese and condensed milk products increased from $963,811.00 in 1905 to $3,300,000.00 in 1911. There is no question but that within the next few years there will be a great development along the lines of agricultural manufactures in this State.

MARKETS.

The markets of Utah for agricultural products are the larger cities and the mining camps. Those who are engaged in the range industry use large quantities of supplies for their maintenance through the season. The sugar factories, flouring mills, canning factories and condensaries also have

large markets in the surrounding States. Much Utah flour is shipped to the Orient.

NATURAL PLANT FOODS.

The maintenance of the fertility of the soil is a leading question in every agricultural State. While the natural fertility of Utah soils is very high, under incorrect practices there may come a time when there will be a shortage of some of the more important plant foods. Nature seems to have provided against this emergency in Utah. Phosphates, which are most likely to be eliminated by improper methods of cultivation, are found in large deposits in Utah, Idaho and Wyoming. The quantity is immense and the availability for plant use is high. Potash is also found within the State in such a way as to make it of great agricultural importance. For instance, the waters of Great Salt Lake contain thousands of tons of potash, which, by the employment of proper methods of isolation, may be secured for the fertilization of Utah soils. Factories will, undoubtedly, be established in the near future for the production of this commercial plant food for the maintenance of our soils. The nitrogenous substances can be readily obtained from the use of nitrogenous crops on our farms.

THE STATE'S AGRICULTURAL WEALTH.

Utah's population, according to the last census, was 373,351, an increase in 10 years of 96,602, or 34.9%. Of these 200,417 or practically 54% are classed as rural or farming population. However, the increase in the rural population in the past ten years is only 18.9%. This Commission feels that some measures ought to be taken to increase the number of people who cultivate the soil. We have 21,676 farms, an increase in ten years of 2,289. The value of all the farm property owned in the State amounts to $150,795,201.00. Of this value $9,482,164.00 are represented in land, $18,063,-168.00 in buildings, $4,468,178.00 in implements and machinery and $28,330,215.00 in livestock. The average size of

Utah farms is 156.7 acres, and the average of the Utah improved farm is 63.1 acres. The average value of the farms in this State is $6,957.00, and the average value of the farm lands is $4,590.00. The average value of farm buildings in the State amounts to $833.00, and the average value of the implements and machinery on each farm is $206.00. The average value of the livestock on each farm is $1,328.00. It is interesting in this connection to note that Utah's farm lands have increased in value from an average of $9.75 per acre in 1900 to $29.28 in 1910. It is also an interesting fact that 77.1% of Utah farms are free from mortagage indebtedness, and that the average debt on the farms under mortgage is $1,294.00, or less than any other western State; the average of the western States being $2,326.00.

SIZE OF UTAH FARMS.

1.4% of Utah farms are under 3 acres, 8.5% are from 3 to 9 acres, 11.7% are from 10 to 19 acres, 25.6% are from 20 to 49 acres, 19.2% are from 50 to 99 acres, 16.9% are from 100 to 174 acres, 6.3% are from 175 to 259 acres, 6% of Utah farms are from 260 to 499 acres, while 2½% are from 500 to 999 acres, and 1.8% of our farms are 1,000 acres or over.

THE FARM HOME.

The farm homes of the State are well adapted to the needs of the farmers. While there are yet remaining a large number of buildings that were constructed in the early pioneer days, whenever these are replaced it is noticed that modern houses are constructed. Many of the barns, also, are of the old type, built in the days of the State's poverty, but the new barns are all of modern size and constructed according to modern methods of sanitation and convenience. There is, however, much to be done in this department of agricultural development, and the Conservation Commission can, no dobut, be of great service in pointing out to the

farmers how more convenient and satisfactory homes and barns can be built, which will increase the joy of living and minimize the labor necessary on the farm.

SOCIAL CONDITIONS.

The social conditions among the agricultural population are of the best. The Mormon Church, which predominates in the agricultural districts, has provided churches and various auxiliary organizations for young and old in all parts of the State. Other churches have done the same. The spiritual welfare of the people, therefore, is well looked after. Schools are found everywhere in the rural districts. In fact, Utah is noted for the fact that she has usually built the schoolhouse first and the church afterwards. Libraries are being established in many towns of the State; and the library and gymnasium movement is growing rapidly throughout the State. The roads of the State are still in a very poor condition. There is here a crying need of organized effort both of the State as well as on the part of the local communities. The Conservation Commission can certainly be of great help in fostering the good roads movement. The State is fairly well supplied with railroads. Some of the most promising sections of the State are still without railroads, but surveys have been made recently and, undoubtedly, within the next few years railroads will be extended to these important agricultural districts. There are few interurban roads. Telephones and telegraphs are found throughout the State. The telephone is now a necessity on the Utah farm. There are both life and fire insurance companies organized within the State which cater to the agricultural population, and it appears that they are being well patronized. Moreover, outside life and fire insurance companies do a flourishing business among the agricultural population of the State. The potable water supply of most of the cities of the State is of excellent quality. There are yet some districts in which water systems should be established. There are excellent opportunities throughout the State for

securing water supplies from mountain springs that would protect the rural communities from the dangers of contaminated water. The fuel supply is good, when coal is considered, for there are immense deposits of coal throughout the State. The wood supply, however, is very limited, and it will be one of the problems of the Forest Service in this State so to care for the forests that the necessary amount of wood fuel may be grown there. Undoubtedly, also the time will come when each farm will have to do something toward contributing to the wood supply of the State. The light supply of the State is excellent. Gas is practically unknown outside of Salt Lake City and Ogden, but a large proportion of the cities of the State are supplied with electric light. The fact that Utah consists of valleys and mountains makes available an abundance of water power which is now being harnessed and converted into electric energy.

CONCLUSION.

The Utah farmers are of a high degree of intelligence. They represent all the States of the Union and most of the civilized countries of the world. Owing to the missionary system of the Mormon Church, a very large proportion of the men have traveled in various foreign countries of the world and are, therefore, richer in worldly experience than most of the agricultural communities of the land. Illiteracy is very low; schools are well patronized, and there is a general desire for a higher intellectual development and for a knowledge of the best methods of furthering the business of agriculture. Of course, there is yet much to be done for the full awakening of the agricultural population. The Agricultural College of Utah, maintained by the State and Federal government, is growing very rapidly. Leading farmers are sending their sons and daughters there to study agriculture and domestic science and related subjects. The State also maintains, under the direction of the Agricultural College, an extensive and comprehensive extension division, which

holds schools of agriculture and domestic science in all the leading rural communities of the State.

The agriculture of Utah is characterized by great natural resources, an intelligent farming population and a new living interest in all that pertains to better methods of agriculture. The problems to be solved for the agricultural advancement in this State are necessarily complex, for all arid countries have special problems which have not been touched by modern, scientific agriculture which was founded largely in countries of abundant rainfall. Utah, however, is abreast with the States that are doing most for the establishment of practices that will fully develop the agricultural resources of the great West. Utah can maintain on her soils twenty times more farmers than she now has; and possibly then, by improved methods of culture, can double or treble the number.

The following bulletins have been prepared under the direction of Dr. Robert Stewart, of the Utah Experiment Station. The expense of securing the data was undertaken by this Commission and the Utah Experiment Station. The Commission is indebted to Dr. E. D. Ball, Director, for permission to publish the data at this time.

THE SOIL OF THE SOUTHERN UTAH EXPERIMENT FARM.

A. Introduction: Historical.
   1. Geological Derivation of Soil.
   2. Location and Cultivation of Farm.
   3. Plan of Farm.
   4. Soil Survey of Farm.

B. Experimental Part.
   1. Physical Composition.
   2. Chemical Investigations.
      (a) Fertility in Soil.
         1. Composition of Plot A.
         2. Composition of Plot B.
         3. Composition of Plot C.

The Soil of the Southern Utah Experiment Station

BY

John A. Widtsoe and Robert Stewart

A. INTRODUCTION.

The soil of the Southern Utah Experiment Farm is a very interesting type: it is highly charged with gypsum and thereby presents a condition unique in reported studies of the soils of America. Gypsiferous soils are characteristic of a large portion of Southern Utah; many of them are derived from shale, others from sandstone, impregnated with gypsum.

1. Geological Derivation of Soil.

The Virgin River drains the western portion of the terraces of the High Plateau country. The High Plateau area is bounded on the north by the rim of the Great Basin, on the west by the Hurricane fault and extends south into Arizona and east into Colorado. The western portion of the Terraces of the High Plateau is cut by the two forks of the Virgin River. Both branches head at the base of the Pink Cliffs and when united form the Virgin River. The Pink Cliffs are located in the southeastern part of Iron County, almost directly east of Kanarra. The Virgin River, therefore, drains all of Washington County and a small portion of Iron County. Both the branches and their many filaments cut through the deposits of the Cretaceous, Jurassic and Triassic, until at St. George the Virgin is cutting through the Permian. The Southern Utah Experiment Farm lies in the Valley of the Virgin near St. George, and the soil has been formed from the weathering of the Terrace country and deposited in its present position by the Virgin River.

We may learn much regarding the nature of the soil of the Southern Utah Experiment Farm by studying the nature of the deposits* of the Cretaceous, Jurassic, Triassic and Permian ages in this vicinity. The deposits of the Cretaceous Age consist largely of light-colored sandstones and clay shales. The Jurassic consists of deposits of almost pure white sandstone over a thousand feet thick, surmounted by deposits of shale containing fossiliferous limestone and some gypsum. The deposits of the Triassic Age consist of highly colored sandstone separated by shaly layers and "not infrequently by bands of almost pure gypsum." Bands of limestone or calcite are not found in this series at all.

The Deposits of the Permian consist of chocolate-colored sandstone and shale, but here the cementing material in addition to gypsum consists of sandy limestone.

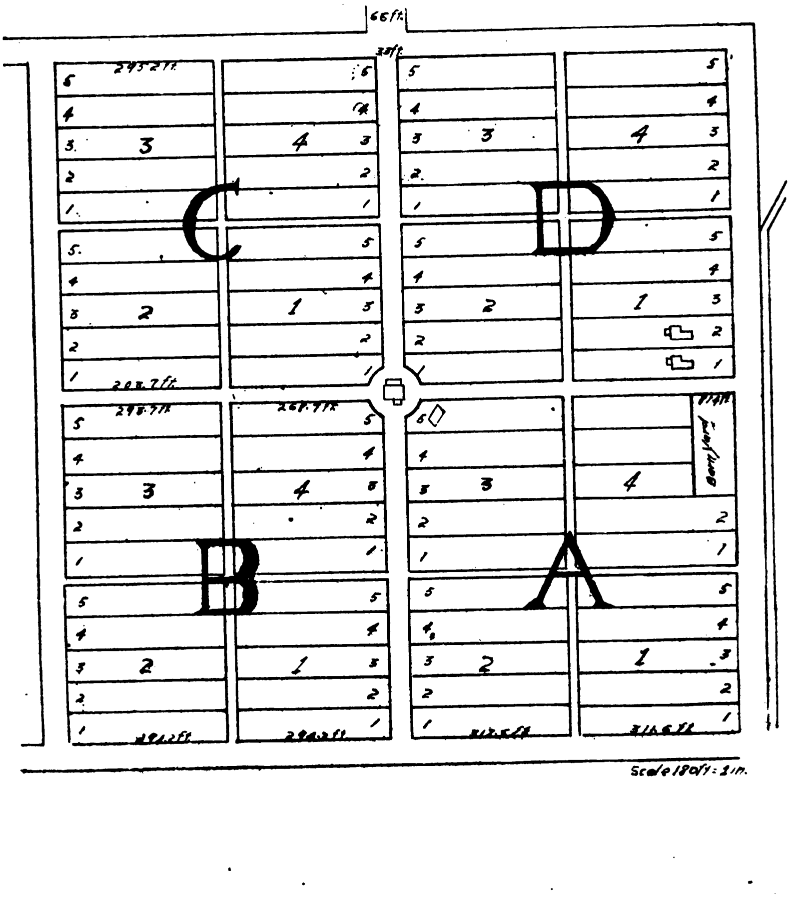
It is from the decomposition materials of these several geological deposits that the soil of the Southern Utah Experimental Farm has been made. Therefore, we would expect to find a sandy soil containing limestone and heavily charged with gypsum.

2. Location and Cultivation of the Farm.

The farm was located by a commission which was appointed for that purpose by authority of an act of the Legislature approved March 21st, 1899. It was accepted (†) by the State Board of Horticulture in December, 1899, and Hon. Thomas Judd was appointed custodian. The farm was located on the Washington field about six and a half miles southeast of St. George. When located, the land was in the virgin state. The custodian in his report to the State Board of Horticulture says: "The condition of the land was such as to necessitate a great amount of work in order to put the property in proper shape. The ground has been cleared of

*U. S. Geological Survey, Vol. II (1885).
†Biennial Report of Utah State Board of Horticulture, 1899-1900.

Plate 1



Utah Farm Scenes. Land in This Vicinity is Valued at $300 per Acre.

sagebrush, (‡) ploughed and mostly leveled, the latter operation requiring an unusual amount of work because of the fact that when water is applied to the soil the land sinks in spots, the depression being from six inches to three feet. After having been thoroughly soaked once and settled, there is no danger of further settling." Since the farm was to be devoted to horticultural purposes, it was planted to grapes, peaches, prunes and other horticultural products and especially to those indigenous to a warm climate.

3. Plan of the Farm.

The farm as located consisted of a forty-acre tract which was divided up into four equal plots of approximately ten acres each and known as Plots A, B, C, and D. Each plot was divided into four equal blocks which were numbered consecutively. Each block was divided into five lots which were numbered consecutively. Each lot, therefore, consists of approximately four-tenths of an acre.

4. Soil Survey of the Farm.

During the summer of 1905 (chiefly in June) a detailed soil survey of the farm was made by J. C. Thomas, under the direction of the Chemical Department of the Experiment Station. Commencing with Lot 1, Block 1, Plat D, every other lot was sampled to a depth of ten feet. Very complete notes were recorded and the samples of soil were shipped to the chemical laboratory, where they were submitted to analysis as described. The field notes indicate that with depth the percentage of clay and gypsum increased. From the sixth foot downward, the moisture content rapidly increased until at the tenth foot in many cases the record

‡True sage brush (*Artemesia tridentata*) does not occur in this locality. Two-thirds or more of the original "Brush" in this section of Washington field was Giant Salt Brush (*Atriplex canescens*). Small amounts of Rabbit Brush (*Bigelovia sp*), Greasewood (*Sarcobatus Baileyii*), Sea Blite (*Suaeda Moquinii*), and scattering specimens of *Atriplex lentiformas Artemesia filifolia* and *Hymenocles fasciculata* occurred throughout this area.

shows only mud. In the laboratory, representative composite samples of the first and third foot samples were submitted to complete chemical analysis. One sample of each block which in turn was a composite of one-half the lots on the block, was submitted to analysis. Thus, four samples of the surface foot and four of the third foot of each plot, which in turn were composites of ten separate borings, were analyzed. Three composite samples of the first, second and fifth feet were submitted to physical analysis to determine the percentages of sand, silt and clay. All of the original samples from the first, second, third, fifth, and tenth feet were analyzed for alkali.

B. EXPERIMENTAL PART.

This part naturally falls into three studies: (1) the physical composition; (2) the fertility; (3) the alkali content of the soil.

1. The Physical Composition.

In Table 1 will be found the results obtained from a physical analysis of the soil as determined by the method described in Bulletin 89 of the Utah Station. These results clearly show that the soil is distinctly of a sandy nature

TABLE I.

PHYSICAL COMPOSITION OF SOIL FROM SOUTHERN EXPERIMENTAL FARM.*

	First Foot.	Second Foot.	Fifth Foot.
Coarse Sand	37.48	38.96	37.31
Fine Sand	23.16	18.62	24.10
Coarse Silt	16.11	12.75	10.88
Medium Silt	8.36	9.47	7.61
Fine Silt	4.91	4.35	3.98
Clay, Water and Loss	9.99	15.85	16.12

*All results in this bulletin are reported as per cent of dry soil. Each result in this table represents the average of seven determinations.

The soil would be classified as a sand or sandy loam. The notes of the surveying party of 1905 indicate that the ground water was near the tenth foot.

2. Chemical Investigations.

The chemical investigations were of two kinds: the determination of the plant food content, and the determination of the alkali content. The plant food content was determined by the methods of the Association of Official Agricultural Chemists.

(a). FERTILITY IN SOIL.

Since the fertility content was determined by the methods of the Association of Official Agricultural Chemists, the results are also reported by their method, i. e., as the oxides of the elements instead of as the elements themselves. There has been considerable agitation of recent years to report such results on the element basis, but since the results obtained by the method followed do not represent the total amount present in the soil, the method of reporting as used by the association has been followed.

1. Composition of Plot A.

Four composite samples of the surface foot of Plot A, representing ten separate borings, and two composite samples of the third foot, representing six separate borings, were submitted to analysis. The results obtained are reported in Tables 2 and 3.

A study of Table 2 indicates some very interesting and important results. The amount of insoluble residue clearly confirmed and the results of the physical analysis of the soil, i. e., that the soil is of a sandy nature. The amount of potash present is normal for arid sandy soils, while the amount of soda present is not high for an arid soil. The amount of calcium present is high and when taken in connection with the percentage of carbon dioxide indicates that

a large part is present in the form of the carbonate. The high percentage of sulphuric acid and the low content of soda indicates that part of the calcium is present as the sulphate. The magnesia content is high, and when the reported toxic action of magnesia is taken into consideration, is very important.

TABLE II.

FERTILITY IN SOIL OF FIRST FOOT OF PLOT A.

Block No.	1	2	3	4	
Lot Nos.	1, 3, 5	2, 4	1, 3, 5	2, 4	Average
Lab. No.	45041	45042	45043	45044	
Insoluble Residue	83.55	76.09	82.32	82.23	81.05
Potash, K_2O	0.63	0.85	0.50	0.54	0.63
Soda, Na_2O	0.76	0.84	0.77	0.84	0.80
Lime, CaO	3.63	5.70	4.67	4.93	4.73
Magnesia, MgO	1.36	3.29	2.33	2.32	2.32
Sulphuric Acid, SO_3	0.13	0.68	0.35	0.24	0.35
Oxide of Iron, Fe_2O_3	2.05	2.76	2.40	2.31	2.38
Alumina, Al_2O_3	3.42	3.74	2.72	1.98	2.96
Phosphoric Acid, P_2O_5	0.064	0.09	0.099	0.11	0.09
Carbon Dioxide, CO_2	3.25	5.57	2.49	3.21	3.63
Difference	1.16	0.39	1.35	1.29	1.05
Total	100.00	100.00	100.00	100.00	100.00
Humus	0.79	0.83	0.64	0.68	0.73
Nitrogen	0.033	0.040	0.0283	0.035	0.034

Loew maintains that the ratio between the lime and magnesia is a very important factor in crop production. Using the average results obtained on Plot A, if we regard the "lime" as all of the calcium present as carbonate, silicate and sulphate, the ratio of magnesia to lime is 1:2.04. If we assume that all of the sulphuric acid exists as calcium sulphate and we subtract the theoretical amount of calcium in this form (.25%) from the total, the ratio of magnesia to lime is 1:1.93.

The amount of phosphoric acid is very low and indicates a deficiency of this material. The humus is very low.

even for arid America, and the nitrogen content is also remarkably low, indicating a deficiency in these two important substances.

In the third foot (see table 3) there is a lower content of potash, soda, nitrogen and humus, while the phosphoric acid is slightly higher in subsoil than in the surface soil. In the third foot, the magnesia-calcium ratios are 1:2.29 and 1:1.5.

TABLE III.

FERTILITY IN THE SOILS OF THIRD FOOT OF PLOT A.

Block No.	1	3	
Lots Nos.	1, 3, 5	1, 3, 5	Average
Lab. No.	45057	45058	
Insoluble Residue	82.78	79.17	80.97
Potash, K_2O	0.21	0.14	0.18
Soda, Na_2O	0.11	0.11	0.11
Lime, CaO	4.40	5.36	4.88
Magnesia, MgO	1.89	2.36	2.13
Sulphuric Acid, SO_3	2.24	2.56	2.40
Oxide of Iron, Fe_2O_3	2.47	1.79	2.13
Alumina, Al_2O_3	1.40	2.63	2.01
Phosphoric Acid, P_2O_5	0.12	0.14	0.13
Carbon Dioxide, CO_2	2.69	3.65	3.17
Difference	1.69	2.09	1.89
Total	100.00	100.00	100.00
Humus	0.31	0.31	0.31
Nitrogen	0.023	0.028	0.0255

2. Composition of Soil of Plot B.

Tables 4 and 5 show that the results for the insoluble residue in Plot B are somewhat lower than for Plot A, but in general the results indicate a sandy soil. The result for Lab. No. 45048 is lower than any of the other three but when taken in connection with the exceptionally high calcium and sulphuric acid content, indicates that the soil of this block is somewhat more heavily charged with gypsum. The soda and potash are normal. The calcium and magnesia

are high. The carbon dioxide is high; the sulphuric acid is also high, and in the case of the soil of block 2 and 4 is exceptionally high. Again, the phosphoric acid is low. The humus is slightly lower than in Plot A, while the nitrogen content is about constant. Again, considering the "lime" as being the total calcium present, the ratio of magnesia to lime in the first foot is 1:2.1, while, subtracting the amount of the oxide in the form of the sulphate from the total oxide present, the ratio is 1:1.9. In case of the third foot, the ratios are 1:2.32 and 1:2.19 respectively.

TABLE IV.

FERTILITY IN THE SOIL OF FIRST FOOT PLOT B.

Block No.	1	2	3	4	
Lots No.	1, 3, 5	2, 4	1, 3, 5	2, 4	Average
Lab. No.	45045	45046	45047	45048	
Insoluble Residue	80.91	77.04	79.65	73.61	77.83
Potash, K_2O	0.43	0.44	0.51	0.73	0.52
Soda, Na_2O	0.64	0.45	0.16	0.14	0.35
Lime, CaO	4.64	5.67	4.66	6.44	5.35
Magnesia, MgO	2.39	3.45	2.05	2.27	2.54
Sulphuric Acid, SO_3	0.55	1.02	0.19	1.50	0.82
Oxide of Iron, Fe_2O_3	2.19	2.45	2.30	2.45	2.34
Alumina, Al_2O_3	2.51	2.72	4.06	5.54	3.70
Phosphoric Acid, P_2O_5	0.10	0.14	0.15	0.24	0.15
Carbon Dioxide, CO_2	4.42	4.68	4.50	5.84	4.86
Difference	1.22	1.94	1.77	1.24	1.54
Total	100.00	100.00	100.00	100.00	100.00
Humus	0.89	0.54	0.60	0.51	0.63
Nitrogen	0.031	0.031	0.028	0.031	0.03

3. Composition of Plot C.

In general as shown by tables 6 and 7 the results for insoluble residue in the soil of this plot are slightly lower than that of the preceding two plots. This is readily accounted for by the increased amounts of sulphuric acid and carbon dioxide which shows a higher amount of gypsum and

TABLE V.

FERTILITY IN THE SOIL OF THIRD FOOT PLOT B.

Block No.	1	3	
Lots No.	1, 3, 5	1, 3, 5	Average
Lab. No.	45059	45060	
Insoluble Residue	81.70	76.15	78.92
Potash, K_2O	0.40	0.58	0.49
Soda, Na_2O	0.22	0.10	0.16
Lime, CaO	4.95	5.90	5.42
Magnesia, MgO	1.81	2.77	2.29
Sulphuric Acid, SO_3	0.64	0.46	0.55
Oxide of Iron, Fe_2O_3	2.01	2.12	2.06
Alumina, Al_2O_3	1.47	3.02	2.24
Phosphoric Acid, P_2O_5	0.17	0.18	0.17
Carbon Dioxide, CO_2	2.06	3.40	2.73
Difference	4.57	5.32	4.94
Total	100.00	100.00	99.97
Humus	0.27	0.49	0.38
Nitrogen	0.022	0.035	0.028

TABLE VI.

FERTILITY IN THE SOIL OF THE FIRST FOOT OF PLOT C.

Block No.	1	2	3	4	
Lots Nos.	1, 3, 5	2, 4	1, 3, 5	2, 4	Average
Lab. No.	45049	45050	45051	45052	
Insoluble Residue	73.80	72.37	78.24	73.09	74.37
Potash, K_2O	0.70	0.78	0.65	0.78	0.73
Soda, Na_2O	0.16	0.19	0.13	0.18	0.17
Lime, CaO	6.27	6.61	5.01	6.16	6.01
Magnesia, MgO	2.86	2.26	2.97	3.59	2.92
Sulphuric Acid, SO_3	1.59	1.04	0.39	0.66	0.92
Oxide of Iron, Fe_2O_3	2.83	2.81	2.40	2.89	2.73
Alumina, Al_2O_3	4.48	5.92	3.54	4.53	4.63
Phosphoric Acid, P_2O_5	0.26	0.31	0.26	0.25	0.27
Carbon Dioxide, CO_2	5.60	5.97	4.11	5.63	5.32
Difference	1.45	1.74	2.30	2.24	1.94
Total	100.00	100.00	100.00	100.00	100.00
Humus	0.60	0.50	0.54	0.56	0.55
Nitrogen	0.028	0.030	0.025	0.028	0.027

calcium carbonate present. The potash is normal, while the soda is very low. The lime, sulphuric acid, carbon dioxide and magnesia are higher. The phosphoric acid is slightly higher. The humus is still low, while the nitrogen content is nearly constant. The ratios of magnesia to lime, obtained as indicated before, are 1:2.05 and 1:1.86, respectively.

In the third foot similar conclusions may be drawn. The ratio of magnesia are 1:2.0 and 1:1.82, respectively.

TABLE VII.

FERTILITY IN THE SOIL OF THE THIRD FOOT OF PLOT C.

Block No.	1	3	
Lots Nos.	1, 3, 5	1, 3, 5	Average
Lab. No.	45061	45062	
Insoluble Residue	77.14	80.52	78.83
Potash, K_2O	0.56	0.45	0.51
Soda, Na_2O	0.20	0.12	0.16
Lime, CaO	5.57	2.44	4.01
Magnesia, MgO	2.98	1.06	2.02
Sulphuric Acid, SO_3	0.42	0.51	0.47
Oxide of Iron, Fe_2O_3	2.32	1.61	1.96
Alumina, Al_2O_3	2.69	2.29	1.47
Phosphoric Acid, P_2O_5	1.18	0.15	0.16
Carbon Dioxide, CO_2	3.59	1.89	2.74
Difference	4.35	8.96	7.67
Total	100.00	100.00	100.00
Humus	0.55	0.51	0.53
Nitrogen	0.029	0.028	0.0285

4. Composition of Plot D.

Table 8 shows that the insoluble residue of the first foot of the soil of Plot D is more nearly like that of Plots A and B. There is less lime present in the form of carbonate. The potash is normal, while the soda is very low. The magnesia is high. The phosphoric acid is lower than in Plot C, but higher than in Plots A and B. The sulphuric acid is very

TABLE VIII.

FERTILITY IN THE SOIL OF THE FIRST FOOT OF PLOT D.

Block No.	1	2	3	4	
Lots Nos.	1, 3, 5	2, 4	1, 3, 5	2, 4	Average
Lab. No.	45053	45054	45055	45056	
Insoluble Residue	76.41	82.20	75.85	79.49	78.48
Potash, K_2O	0.46	0.51	0.51	0.37	0.46
Soda, Na_2O	0.15	0.12	0.12	0.11	0.12
Lime, CaO	5.82	4.35	6.04	5.27	5.37
Magnesia, MgO	2.30	1.89	3.08	2.25	2.37
Sulphuric Acid, SO_3	2.23	0.82	1.95	2.76	1.94
Oxide of Iron, Fe_2O_3	2.11	1.91	2.24	1.72	1.99
Alumina, Al_2O_3	1.35	3.13	3.33	2.21	2.50
Phosphoric Acid, P_2O_5	0.23	0.18	0.21	0.13	0.187
Carbon Dioxide, CO_2	4.08	3.49	5.25	3.66	4.12
Difference	4.86	1.40	1.42	2.05	2.42
Total	100.00	100.00	100.00	100.00	100.00
Humus	0.54	0.46	0.42	0.33	0.43
Nitrogen	0.024	0.022	0.027	0.035	0.02

TABLE IX.

FERTILITY IN THE SOIL OF THIRD FOOT OF PLOT D.

Block No.	1	3	
Lots Nos.	1, 3, 5	1, 3, 5	Average
Lab. No.	45063	45064	
Insoluble Residue	73.70	69.59	71.65
Potash, K_2O	0.77	0.76	0.77
Soda, Na_2O	0.15	0.18	0.17
Lime, CaO	6.11	6.88	6.49
Magnesia, MgO	3.46	4.21	3.83
Sulphuric Acid, SO_3	1.58	3.15	2.36
Oxide of Iron, Fe_2O_3	2.85	2.63	2.74
Alumina, Al_2O_3	3.55	3.72	3.63
Phosphoric Acid, P_2O_5	0.22	0.23	0.23
Carbon Dioxide, CO_2	4.22	6.38	5.30
Difference	3.39	2.27	2.83
Total	100.00	100.00	100.00
Humus	0.79	0.69	0.74
Nitrogen	0.034	0.042	0.038

high. The humus is very low. The nitrogen is practically the same as in the other plots. The ratios of magnesia to lime are 1:2.27 and 1:1.70, respectively.

In the third foot (see Table 8) the insoluble residue is much lower, which is due to the excess of lime in the form of gypsum. It is important to note that as the sulphuric acid increases the magnesia likewise slightly increases. The phosphoric acid and nitrogen are nearly the same. The humus is slightly higher. The ratios of magnesia to lime are 1:1.69 and 1:1.3, respectively.

5. The Farm as a Whole.

In Table 10 will be found the average of sixteen analyses of the surface foot of soil and the average of eight analyses

TABLE X.

AVERAGE FERTILITY OF THE SOILS OF SOUTHERN EXPERIMENTAL FARM.

	Composition of surface foot. Average of 15 analyses.	Composition of third foot Average of 8 analyses.
Insoluble Residue	77.93	77.60
Potash, K_2O	0.58	0.49
Soda, Na_2O	0.36	0.15
Lime, CaO	5.37	5.20
Magnesia, MgO	2.54	2.57
Sulphuric Acid, SO_3	1.01	1.44
Oxide of Iron, Fe_2O_3	2.36	2.22
Alumina, Al_2O_3	3.45	2.34
Phosphoric Acid, P_2O_5	0.17	0.17
Carbon Dioxide, CO_2	4.49	3.48
Difference	1.74	4.34
Total	100.00	100.00
Humus	0.58	0.49
Nitrogen	0.029	0.0214

of the third foot of soil. These results ought to represent pretty well the average composition of the farm as a whole.

The uniformity of the results for the first and third foot samples is remarkable. With the exception of the low results for alumina in the third foot and the high difference, the results for the two foot sections are almost the same.

When taken in connection with the high lime contents in the form of sulphate and carbonate, the results for insoluble residue are normal for a sandy soil. The amount of potash and soda are normal. The phosphoric acid, humus and nitrogen are low. The humus and nitrogen especially are remarkably low, and indicate a serious deficiency which which we would expect to be felt soon in crop production. The ratios of magnesia to lime in the first foot are 1:2.1 and 1:1.9, respectively, while in the third foot they are 1:2.0 and 1.7, respectively.

In a study of these results we must keep in mind the fact that there are ten essential elements of fertility. If any one of these elements is deficient the crop will not grow normally. These ten elements of fertility are, carbon, oxygen, hydrogen, nitrogen, calcium, iron, sulphur, magnesium, potassium and phosphorus. The carbon and oxygen are obtained from the air, the hydrogen from the water, while the nitrogen is obtained chiefly from the organic matter of the soil. The remaining six, calcium, iron, sulphur, magnesium, potassium and phosphorus are obtained from the soil. Of these, calcium, magnesium, iron and sulphur occur in the soil and especially in the soil of Utah to such an extent that their supply is apt never to become exhausted. We are coming more and more to realize that such also is the case with potassium. The hydrogen is obtained from the soil water and the people of Utah realize the importance of a supply of soil moisture. The two remaining elements, phosphorus and nitrogen, are deficient in our soils and the maintaining of the supply of these two elements forms the problem of soil fertility over a large area of our State.

6. THE POTASSIUM PROBLEM.

The amount of potassium (socalled Potash) in the soils of the Southern Utah Experiment Farm is normal for sandy soils. The method of analysis used does not give all of the potassium which is present in the soil but only about, in general terms, one-fourth of the total amount present. While potassium is one of the essential elements of plant food and is usually regarded as one of the three most likely to be deficient in the soil, it is the least important of the three socalled essential elements of plant production. When the products of the farm are fed to the animals, very little if any of this element is retained by the animal, but is all voided in the waste products of the body and may with care be returned to the soil. It occurs in the soil in far greater quantities than nitrogen or phosphorus and is not utilized by the animal body so extensively as the other two. The potassium problem for the farmer then is to so control the operations on the farm as to liberate the potassium from its insoluble compounds and render it available for plant production. Now it so happens that decomposing organic matter is the key which unlocks the sealed door and liberates the potassium. The soils of St. George need organic matter for this purpose. The results for humus indicate a marked deficiency in organic matter which may be added in one of two ways: either by adding barnyard manure or ploughing under crop residues or crops grown for that purpose. Crops which are used for the purpose of adding organic matter to the soil should belong to the leguminous family (that is, peas, lucern, etc.,) in order, also, to make use of the nitrogen of the air.

7. THE PHOSPHORUS PROBLEM.

Phosphorus is deficient in the soil of the Southern Utah Experiment Farm. If no provision is made for the return of this important plant food the time is not far distant when a marked deficiency will result, and it will become the limiting element of plant production. There are two ways in

which this material may be added to the soil: First, it may be added in the form of barnyard manure, but a ton of barnyard manure only contains two pounds of phosphorus, so if the supply is to be maintained in this way large quantities of manure must be added; second, it may be added in the form of the commercial product, either as the superphosphate or in the raw state. The addition of the material as the raw rock phosphate is advisable under certain conditions, provided sufficient decomposing organic matter is present to convert it into the available form. If the value of the crops produced is sufficient to warrant it, a more available and therefore a higher priced product, may be purchased. The economical use of commercial fertilizers, must be subjected to experiment before reliable advice can be given on this point.

8. The Nitrogen Problem.

Nitrogen is undoubtedly the limiting element of crop production in this soil. The amount present is only 0.028 per cent, and the amount is practically constant with depth. The ploughed surface of this soil to a depth of say seven inches would weigh approximately 2,000,000 pounds per acre. Therefore, there would be only 560 pounds of nitrogen in this much soil, while one year's growth of the number of apple trees necessary to produce a 600 bushel crop of apples would remove 112 pounds of nitrogen per acre. It can thus be readily seen that nitrogen is the limiting element of plant production of this soil, and that nitrogen must be added in some form or another and that very soon.

All of the nitrogen of the soil must first be converted from the organic form to the form of nitrates by the process of nitrification before it can be utilized for plant production. Nitrification is a process which is caused by the action of bacteria. These bacteria must have oxygen for their growth and it has been determined for our arid soils that this process does not ordinarily take place to any appreciable extent below four feet. Therefore, the nitrogen avail-

able even for a deep rooted plant like a tree would only be that in the first four feet. The first four feet of the soil of this farm would weigh approximately 16,000,000 pounds and the maximum amount of nitrogen available for crop production in the surface four feet of soil would be 4480 pounds, a little more than the average contained in the ploughed surface of sandy soils of America. That is, there would be enough nitrogen present to support an orchard for not over forty years. But it is probable that long before that time the orchard would be nitrogen hungry. This is not theory but calculated facts based upon accurate chemical and mathematical data. The following table compiled by Hilgard* can be profitably studied in this connection.

TABLE XI.

Practical Rating of Soils by Plant Food Percentages, According to Professor Maercker, Halle Station, Germany.

Grade of Soil.	Potash.	Phosphoric Acid.	Lime. Clay Soil.	Lime. Sandy Soil.	Total Nitrogen.
Poor	Below 0.05	Below 0.05	Below 0.10	Below 0.05	Below 0.05
Medium	0.05—0.15	0.05—0.10	0.10—0.25	0.10—0.15	0.05—0.10
Normal	0.15—0.25	0.10—0.15	0.25—0.50	0.15—0.20	0.10—0.15
Good	0.25—0.40	0.15—0.25	0.50—1.00	0.20—0.30	0.15—0.25
Rich	Above 0.40	Above 0.25	Above 1.00	Above 0.30	Above 0.25

	Potash.	Phosphoric Acid.	Lime.	Nitrogen.
Average for California	0.70	0.08	1.08	0.11
Average for Arid Region	0.73	0.12	1.36	0.11
Average for Humid Region	0.22	0.11	0.11	0.12

The nitrogen which is so markedly deficient in the soil of this farm may be added in one of three ways, by the addition of barnyard manure, ploughing under of legumes, or purchase of commercial nitrogen.

Another way of emphasizing the same truth is to consider the ability of this soil to produce some common farm product. The sugar beet is a common crop in Utah, although

* Hilgard, Soils, p. 369.

it is not grown in this section and probably never will be. A twenty-ton crop would be regarded as a good crop for Utah soils to produce although many of our soils do far better. The soils of the Southern Utah Experiment Farm contains only 560 pounds of nitrogen in the ploughed surface of the soil. Assuming that the beet crop can draw on the food supply of the full surface foot of soil, there would be available 1020 pounds of nitrogen for the production of a sugar beet crop. A twenty-ton crop of sugar beets would remove from the soil 100 pounds of nitrogen. There would be, therefore, only nitrogen enough for eleven such crops in this soil. Of course under such conditions maximum crops of twenty tons would be impossible and the soil would probably produce indifferent crops from the beginning. Nitrogen is the limiting element of crop production in this soil.

b. ALKALI IN THE SOIL.

The "alkali" in the soil was determined as follows: 50 grams of the soil were treated with 500 cc of distilled water and allowed to stand with occasional shaking for 24 hours. The aqueous extract was separated from the residue by filtration with a Chamberlain-Pasteur filter. An aliquot portion of the filtrate was evaporated to dryness and the residue weighed. This weight represents the total "alkali" or water-soluble salts. A second portion of the filtrate was used for the determination of chlorine by the silver nitrate volumetric method. The chlorine found was reported as sodium chloride. The residue obtained from the determination of the total salts was redissolved in water with the addition of a few drops of hydrochloric acid, and in this solution the sulphuric acid was determined by precipitation with barium chloride as barium sulphate. In a third portion of the filtrate the amount of calcium was determined and the results reported as hydrated calcium sulphate. Any excess of sulphuric acid was regarded as combined with sodium and reported as sodium sulphate. A fourth portion of the filtrate was used for the determination of black alkali by tritration

against a $\frac{N}{10}$ sulphuric acid solution. The result was reported as sodium carbonate.

TABLE XII.

Average Composition of Alkali in Plot A.

(Each result is the average of ten separate determinations.)

Depth	1st foot.	2d foot.	3d foot.	5th foot.	10th foot.
Total Soluble Salts	0.58	1.57	2.30	2.41	2.77
Calcium Sulphate	0.29	1.53	1.90	2.03	2.34
Sodium Chloride	0.03	0.04	0.02	0.05	0.06
Sodium Carbonate	0.09	0.07	0.07	0.07	0.10
Sodium Sulphate	0.10	0.22	0.41	0.29	0.29

1. Alkali In the Soil of Plot A.

In the first foot of Plot A there is a total soluble salt content of 0.58 per cent. The total increases with depth to a maximum in the tenth foot. This increase is due to the increase in the percentage of gypsum or calcium sulphate as is distinctly shown in table 12. The amount of sodium chloride, or common salt, is very small and is constant with depth. The content of sodium carbonate is small and is almost constant with depth. The sodium sulphate is small and the content increases slightly with depth. A careful study of the table clearly shows that an average of 88 per cent of the water soluble salts or total "alkali" consists of gypsum.

2. Alkali in Soil of Plot B.

A study of Table 13 shows that the total soluble salts in the first two feet are slightly higher than in the corresponding portion of Plot A. The total soluble salt content in the deeper portions is practically the same as in Plot A. Again, the increase is due to an increase of gypsum. The sodium chloride and sodium carbonate contents are practically the same as before. The sodium sulphate content is

slightly lower. A study of this table shows that 83 per cent of the total water-soluble salts or "alkali" is gypsum.

TABLE XIII.

Average Composition of Alkali in Plot B.

(Each result is the average of ten separate determinations.)

Depth	1st foot.	2d foot.	3d foot.	5th foot.	10th foot.
Total Soluble Salts...	0.98	2.33	2.21	2.29	2.52
Calcium Sulphate.....	0.74	2.06	1.99	1.98	1.98
Sodium Chloride......	0.04	0.09	0.03	0.03	0.03
Sodium Carbonate....	0.07	0.05	0.05	0.05	0.06
Sodium Sulphate......	0.07	0.02	0.15	0.20	0.02

3. Alkali In Soil of Plot C.

A study of Table 14 shows that the total alkali content is slightly greater in the surface foot of Plot C, as compared with the other plots, and that the increase again is due to an increase of gypsum. In the lower depths, the total salts and the gypsum differs little from that of the previous plots. The sodium chloride is slightly higher. The sodium carbonate is practically the same as before and is constant with depth. The sodium sulphate is practically the same as before. A study of the table shows that 80 per cent of the water-soluble salts is in the form of gypsum.

TABLE XIV.

Average Composition of Alkali in Plot C.

(Each result is the average of ten separate determinations.)

Depth	1st foot.	2d foot.	3d foot.	5th foot.	10th foot.
Total Soluble Salts...	1.24	2.10	2.51	2.18	2.84
Calcium Sulphate.....	0.90	1.57	2.11	1.84	2.42
Sodium Chloride.....	0.08	0.12	0.06	0.05	0.04
Sodium Carbonate....	0.06	0.06	0.06	0.06	0.07
Sodium Sulphate.....	0.16	0.25	0.34	0.16	0.22

4. Alkali In Soil of Plot D.

A study of Table 15 shows a marked increase in the water-soluble salts and that the increase is due in the main to an increase of gypsum. The sodium chloride is lower than in Plot C, and is constant with depth. The sodium carbonate is higher in the surface foot. The sodium sulphate is higher throughout. Again we learn by a study of the table that 78 per cent of the water-soluble salts consists of gypsum.

TABLE XV.

Average Composition of Alkali in Plot D.

(Each result is the average of ten separate determinations.)

Depth	1st foot.	2d foot.	3d foot.	5th foot.	10th foot.
Total Soluble Salts...	2.34	2.82	2.87	2.66	2.80
Calcium Sulphate.....	1.60	2.16	2.49	2.14	2.16
Sodium Chloride.....	0.04	0.05	0.05	0.04	0.04
Sodium Carbonate....	0.16	0.08	0.06	0.06	0.06
Sodium Sulphate.....	0.31	0.24	0.35	0.28	0.31

5. Average Composition of the Alkali in the Soil of the Farm.

The results given in Table 16 are the average of forty separate analyses and therefore indicate the truth very closely. The total salts are at a minimum in the surface soil and increase to a maximum in the tenth foot. The calcium sulphate increases in the same order. The sodium chloride content is small and is practically constant with depth. The sodium carbonate approximates one-tenth of one per cent and decreases slightly with depth. The sodium sulphate approximates about two-tenths of one per cent, and varies very slightly with depth. The table indicates that 81 per cent of the total salts or total "alkali" is in the form of gypsum.

TABLE XVI.

Average Composition of Alkali in Southern Utah Experiment Station.

(Each result is the average of forty separate determinations.)

Depth	1st foot.	2d foot.	3d foot.	5th foot.	10th foot.
Total Soluble Salts	1.29	2.20	2.47	2.39	2.73
Calcium Sulphate	0.91	1.83	2.14	1.99	2.22
Sodium Chloride	0.05	0.07	0.04	0.04	0.04
Sodium Carbonate	0.10	0.07	0.06	0.06	0.07
Sodium Sulphate	0.16	0.18	0.31	0.23	0.21

7. The Analysis of Composite Samples.

The significance of the results obtained led us to confirm the method of calculation of the chlorides, carbonates and sulphates by the complete analysis of representative samples. Therefore, four composite samples representing the first, third, fifth and tenth feet were made by weighing out 10 grams of each of the foot sections corresponding to those represented in Table 16. The averages of the determinations are given in Table 17.

TABLE XVII.

Composition of Water-Soluble Material of Composite Samples.

(Results reported as per cent of dry soil.)

Lab. No.	71233	71234	71235	71236
Depth of Sample	1st foot.	3d foot.	5th foot.	10th foot.
Total Solids	1.55	2.67	2.68	2.85
Sodium Chloride	0.043	0.037	0.033	0.038
Sodium Sulphate	0.148	0.086	0.118	0.091
Potassium Sulphate	0.045	0.036	0.030	0.029
Sodium Carbonate	0.052	0.052	0.075	0.097
Hydrated Calcium Sulphate	1.340	2.410	2.430	2.470

One hundred grams of each of these composite samples were extracted with one litre of distilled water for twenty-four hours, filtered through a Chamberlain-Pasteur filter and the solution thus obtained was submitted to analysis. Actual

determinations were made of potassium, sodium, sulphuric acid, chlorine, calcium, magnesium, and aluminum. From this data calculations were made of the probable state of combination in which the various substances occurred in the soil. The results obtained are reported in Table 17. The results obtained confirm in an emphatic way those already obtained, as may be readily seen by comparing this Table with Table 16. The sodium chloride and the sodium carbonate are in remarkable accord. Total salts are slightly higher, due to the greater extraction of gypsum. The results indicate that some potassium sulphate is present and when taken into consideration with the presence of water-soluble alumina would seem to indicate the existence of a little potassic alum in the soil. The conservative character of the method followed of estimating the sulphates may be readily seen by an examination of Table 18. In this table the sulphates calculated from the excess sulphuric acid and reported as sodium sulphates are compared with the sodium and potassium sulphates as calculated from the actual determination of sodium potassium. These determinations clearly indicate that the method of reporting the sulphates at any rate fully reports all of the sulphate present in the form of alkali sulphates.

TABLE XVIII.

Sulphates as Calculated and Reported. Sodium and Potassium Sulphates as Determined.

Depth of Sample	1st foot.	3d foot.	5th foot.	10th foot.
Sulphates as Calculated	0.27	0.25	0.13	0.20
Sodium and Potassium Sulph...	0.19	0.12	0.15	0.12

The method of reporting the calcium sulphate is also very conservative. This may be demonstrated by a study of Table 19. In this table the hydrated calcium sulphate as calculated from the calcium and reported, is compared with hydrated sulphate as calculated from all of the sulphuric acid

present and also as calculated from the loss of water of crystallization (1) when the total solids are heated with a blast lamp.

TABLE XIX.

Calcium Sulphate as Determined by Several Methods.

Depth of Sample.............	1st foot.	3d foot.	5th foot.	10th foot.
Calculated from Water of Crystallization	1.69	2.65	2.71	2.86
Calculated from Sulphuric Acid.	1.67	2.51	2.58	2.71
Calculated from Calcium.......	1.34	2.41	2.43	2.47

The results clearly indicate that only the minimum amount of calcium sulphate actually present has been reported. The slight excess of calcium sulphate as calculated from the water of crystallization offers additional evidence of the existence of some potassic alumina sulphate which has 24 molecules of water of crystallization.

8. Discussion of the Alkali Problem.

A consideration of the data pertaining to alkali in this soil would not cause it to be classified as an alkali soil. It is difficult to determine what percentage of the sulphate, carbonate, and chloride of sodium may be present and yet not be detrimental to plant growth. All may be present in greater or smaller quantity in all our arid soils, even in the best agricultural soils that we have. The important question is: What is the maximum amount which may be present and yet not be detrimental to crop production? This amount undoubtedly varies with the kind of soil and the treatment it receives. Hilgard, for the sandy soil of the Tulare sub-station, gives the percentage as one-tenth of one per cent of sodium carbonate, one-fourth of one per cent

1. The water of crystallization was determined by Mr. Wallace Macfarlane in a piece of crystallized gypsum, obtained near the farm, from a ledge which had undoubtedly contributed to the formation of the soil. Very concordant duplicate determinations showed conclusively that the gypsum contained two molecules of water of crystallization.

of sodium chloride and forty-five to fifty-one hundredths of one per cent. of sodium sulphate. In no case in the soil of this farm does the percentages approach these limits but fall far below them. Of course the soil is different. The presence of gypsum and its effect, favorable, or unfavorable, is an unknown factor. It may be that in the presence of gypsum the plant can withstand a greater or less amount of alkali. This needs to be determined by careful experimentation in the greenhouse. We do know, however, that gypsum is one of the most powerful plant stimulants we have. The presence of such amounts of gypsum as are present would cause the plant to make a rapid growth* as long as sufficient plant food was available, but as soon as the supply of one or more of the essential elements had been nearly exhausted the gypsum would still stimulate the plant to greater growth, but one of the essential foods being lacking the plant would be in a weakened condition and under such conditions would be unable to resist external influence such as in roads of plant diseases, effect of alkali, action of frost. Under normal conditions, such an amount of alkali would not be considered harmful but under the conditions of this farm it may be. The deficiency of nitrogen, however, is the fundamental cause of non-production and this deficiency must be made up first. The plant, like the animal, demands a balanced food. It would be difficult to secure even under artificial conditions a more unbalanced food than we actually have in the soil of this farm. The supply of nitrogen is limited, while the gypsum is constantly liberating the potassium and the essential elements from their insoluble compounds, and as a result we have too much available potassium and other elements and too little nitrogen. The natural result is a weakened condition of the plant and as a result there is liability to disease and death. Sometime in the future conditions may arise such as to render drainage

* It is the common experience of farmers in this district that fruit trees make a marvelously rapid growth during the first few years of their life.

necessary. Conditions may actually be such now as to render drainage necessary. But drainage alone is absolutely useless. It will not remove the cause of the trouble, but only magnify the trouble, since drainage will not only remove the alkali, but also the soluble nitrogen. These investigations do not necessarily solve the problem of the non-productiveness of this soil, but they furnish a basis upon which an intelligent solution of the problem may bė made and the soil converted in a productive one.

9. Acknowledgments.

The authors wish to acknowledge their indebtedness to Mr. W. C. Snow, formerly Assistant Chemist, for the complete analysis of the soil, and to Mr. Wallace Macfarlane, Assistant Chemist, who made the complete alkali analysis of the composite samples.

CONCLUSIONS.

1. The soil of the Southern Utah Experimental Farm has been formed by the Virgin River, which has carried the material from the Terrace country of the High Plateaus.

2. The soil of this farm is very sandy in nature and contains crystalized gypsum.

3. The soil contains a normal amount of potassium, but a low amount of phosphorus and is extremely deficient in humus and nitrogen.

4. Nitrogen is the limiting element of plant production

5. The soil contains a good supply of the other essential elements of plant food and well supplied with calcium carbonate. It contains a high percentage of magnesium.

6. The soil would not be classified as an alkali soil. although it contains small amounts of sodium chloride, sodium sulphate, and sodium carbonate.

7. The plot which is now producing the best crops (Plot D), contains the highest amount of alkali.

8. The soil contains a high percentage of water-soluble salts, but four-fifths of this "alkali" is gypsum, or hydrated calcium sulphate.

9. Conditions may arise in the future which will render drainage necessary, but drainage now alone will only aggravate the trouble.

10. Since the maximum supply of nitrogen is only sufficient for the maximum production of a producing orchard for forty years, the problem of adding nitrogen to the soil must be solved first of all.

11. These investigations ought to serve as a basis for the intelligent solution of the problem of non-productivity of the soil and help the converting of the soil into a very productive and profitable one.

The Nature of the Dry Farm Soils of Utah

By John A. Widtsoe and Robert Stewart.

Successful farming in Utah is dependent upon two main factors: First, the economic use of irrigation water upon the lands lying under the irrigation ditch, and second, upon the correct practice of the principles of dry farming upon those lands not susceptible to irrigation. Dry farming in Utah is, therefore, of great importance and it becomes essential to learn something of the nature of the dry farming soils of the State.

LOCATION AND SURVEY OF THE STATE DRY FARMS.

In 1903 the State of Utah established six experimental farms in widely distributed parts of the dry farming section of the State. These farms were located in the counties of Juab, San Juan, Sevier, Iron, Tooele and Washington. These farms when established were in the virgin condition and supported luxuriant growths of sage brush. At the time of clearing the land for cultivation a very exhaustive soil survey was made. Numerous borings were made where possible to a depth of ten feet.

The Juab county farm was located in Juab Valley, about five miles south of Nephi, on the north slope of the Levan ridge. Four samples of soil representative of the first, third, fourth and ninth feet were submitted to chemical and physical analysis, while nine other samples were submitted to physical analysis, and in addition the nitrogen, humus and carbon dioxide were determined in all of the samples studied. Each sample studied is in turn the composite of a great number of representative borings on the same tract of ground.

The San Juan county farm is located six miles south of Monticello. Four samples representing the first, sixth and seventh feet were submitted to chemical and physical analysis, while eight other samples were submitted to physical analysis.

The Sevier County farm is located in Grass Valley about fifteen miles east of Richfield. Two samples of soil representing first and fourth feet were submitted to chemical and physical analysis, while thirteen others were submitted to physical analysis.

The Iron County farm is located near Parowan in Iron County. Four samples representing the first, fourth and ninth feet were submitted to chemical analysis, while thirteen others were submitted to physical analysis.

The Tooele County farm is located in the Tooele Valley near Grantsville. Two samples representing the first and fourth feet were submitted to chemical and physical analysis, while eight other samples were submitted to physical analysis.

The Washington County farm is located in Washington County near Enterprise. Three representative samples were submitted to chemical analysis, while nine others were submitted to physical analysis. Each of the samples analyzed in every case is the composite sample of several separate borings on a forty acre tract and is therefore very representative of the type of soil studied.

2. Geological Derivation of the Soils.

Five of the six farms are located in the Great Basin, while the sixth, the San Juan farm is located in the High Plateau country with its drainage into the Colorado River Three-fifths of the State, comprising the western part, lies in the Great Basin, while two-fifths is divided into the Uinta-White Basin and the High Plateau country.

The section represented by the Juab County farm was not under water at the time of Lake Bonneville. The waters

of the Lake Bonneville covered only the lower part of the valley, but the dry farming section is just beyond the lower extension of Utah bay of old Lake Bonneville. The soil of the Juab valley, however, has been derived from the weathering from the adjacent mountain ranges. These ranges contain deposits of limestone and extensive deposits of gypsum. It is possible that the phosphate deposit extends to these mountains while deposits of potassium have recently been reported. These facts must be taken into consideration in a discussion of the results obtained.

The dry farming section represented by the San Juan County farm lies in the High Plateau country in the southeast part of the State to the east of the Colorado River. The section is seamed by many deep washes due to occasional torrential rains. The High Plateau country is differentiated from the Great Basin by many geological characteristics. The rock material is composed of shale and sandstone. The San Juan County farm is composed of the weathering of sandstone containing occasional layers of gypsum.

The section represented by the Sevier County farm is located in Grass Valley far above old Lake Bonneville, but is still in the Great Basin area. The soil of the valley has been derived from the erosion of the adjacent mountain ranges.

The soil of the Iron County farm has been derived by the erosion of the adjacent mountain ranges. The valley in which the farm is located was not covered by the waters of Lake Bonneville but is separated from Escalante Bay by a low range of mountains.

The region represented by the Tooele County farm is in the Lake Bonneville district being located in the Tooele Valley, an arm of the Lake. During the Lake period this bay received the storm waves of the open lake. Wave excavation of the alluvial slopes of western base of the Oquirrh mountains contributed to the soil formation.

The region represented by the Washington County farm lies in the Great Basin, being located on the north slope of

the rim of the basin leading down into Escalante Bay of Lake Bonneville. The waters of the lake, however, did not cover the region represented by the farm.

The soils representing these farms being located in widely distributed sections of the State and being derived in such diverse ways offer an interesting group for study. Five of the farms are located in the Great Basin, four of these being above the waters of Lake Bonneville, while the soil of the fifth was formed during the time of Lake Bonneville. The sixth is located in the High Plateau country and probably represents soil formed in place by the weathering of sandstone.

3. The Physical Composition of the Soils.

The method of analysis as developed at this Station was used in making the physical analysis of the soil. The results obtained from the analysis of the Juab County soils are reported in Table 6 in the back of the bulletin. (1). These results indicate that the soil of this farm is a clay loam with a tendency with depth to approach a loam condition.

The results obtained by the analysis of the San Juan County soils are recorded in Table 6. These results indicate that the soil is a sandy soil and that it is quite uniform with depth. The amount of water soluble salts is very low.

The results obtained from a physical analysis of the Sevier farm are recorded in Table 7. These results indicate that the soil is of a very coarse sandy nature with considerable gravel present.

The results for the physical analysis of the soil of the Iron County farm are recorded in Table 7. The results indicate that the soil of the farm is a sandy loam, with a slight tendency to become heavier with depth.

The results obtained from a physical analysis of the soils of the Tooele County farm are recorded in Table 8. These results indicate that the soil of this farm is a sandy

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CAINEVILLE, WAYNE COUNTY.

A typical valley of Southern Utah, which is in need of a railroad.

loam and that it is uniform with depth. The surface soil of the farm presents a fairly uniform surface with, however, an occasional gravel or clay spot. The water soluble salts are somewhat higher in the soil of this farm than in that of the other farms.

The results for the physical analysis of the soil of this farm are recorded in Table 8. These results clearly indicate that the soil of this farm is of a distinct sandy nature and becomes more so with depth. The water soluble salts are very low.

In a discussion of the plant food content of soils it should be clearly kept in mind that there are ten elements of plant food, namely: carbon, hydrogen, oxygen, calcium, magnesium, iron, sulphur, phosphorus, potassium and nitrogen. The plant obtains its carbon from the carbon dioxide of the atmosphere, while the oxygen is obtained either from the soil moisture or from the carbon dioxide of the air. The hydrogen is obtained from the soil moisture. Calcium, magnesium, iron and sulphur are used by all plants in such small quantities and occur in all soils in such large quantities that their supply in most soils is apt never to become exhausted. The remaining three elements of soil fertility, phosphorus, potassium, and nitrogen are used by plants in such large quantities and concentrate in the seed or more salable products of the farm that their supply may become exhausted in the soil. These are the elements of plant food which have a commercial value. The question of soil fertility from the plant food point of view has to do largely with these elements.

The complete data regarding the chemical composition of the soils is recorded in the tables in the appendix. From this data the following tables have been compiled.

4. The Phosphorus Content.

Phosphorus is one of the essential elements of plant food which is usually added in large amounts to soils. The phos-

phorus content of the soils of the several farms is recorded in the following table.

TABLE I.

Acid Soluble Phosphorus in First Foot of Arid Farm Soil.

County	Juab.	San Juan.	Sevier.	Iron.	Tooele.	Washington.
Per ct. Phosphoric Acid, P_2O_5........	0.419	0.24	0.26	0.23	0.31	0.24
Per ct. Phosphorus.	0.182	0.104	0.114	0.100	0.135	0.104
Pounds of Phosphorus per 2,000,000 pounds of soil...	3,640	2,080	2,280	2,000	2,700	2,080

The phosphorus content is high in the Juab and Tooele County farms and considerably lower in the soil from San Juan, Iron and Washington counties. The high content in the Juab soil is probably due to the existence of a phosphate ledge in the mountains to the east. The total phosphorus was also determined in the Juab County soils. The amount in the first foot is 0.191 per cent or 3820 pounds per acre or a difference of 180 pounds of phosphorus i. e. 95% of the phosphorus is acid soluble.

Consultation of the tables in the back part of the bulletin will show that the phosphorus content in the soil of the Nephi farm decreases slightly with depth, while in the San Juan County soil it decreases markedly with depth, there being only a third as much in the seventh foot as in the first.

The phosphorus content in the soil of the Iron County farm is very uniform with depth, while in the Tooele county soil there is a marked decrease with depth. The phosphorus in the soil of the Washington County farm is practically constant with depth. It is thus seen that the dry farming soils of this State are fairly well supplied with phosphorus. The phosphorus content of the average crust of the earth is 2200 pounds per million pounds of soil, while the average phosphorus content of humid soil and arid soils is 1044 and 1392 pounds per two million pounds of soil respectively as given by Hilgard.

Thus while our dry farm soils are well supplied with phosphorus it may become necessary in the future to add phosphorus in some form to our soils.

5. The Potassium Content.

Potassium is a second element of fertility which is applied to soils and thus has a commercial value. In many soils such as peaty swamp lands it is the limiting element of crop production. The potassium content in the dry farm soils is indicated in the following table.

TABLE II.

Acid Soluble Potassium Content in the First Foot of the Dry Farming Soils.

County	Juab.	San Juan.	Sevier.	Iron.	Tooele.	Washington.
Per ct. Potash, K_2O..	1.31	0.83	0.83	0.55	0.95	0.87
Per ct. Potassium...	1.09	0.689	0.689	0.456	0.788	0.722
Pounds of Potassium per two million pounds of soil....	21,800	13,780	13,780	9,120	15,760	14,440

The total amount of potassium in the Juab County soils was also determined. The analysis gave 2.32 per cent potassium in the first foot or 46400 pounds of potassium in the plowed surface of the soil. The acid soluble potassium is, therefore, only 49 per cent of the total amount of potassium present in the soil. In the production of wheat only 7.5 pounds of potassium is necessary for the production of 25 bushels of grain, while 22.5 pounds are needed for the production of the straw. If, therefore, all the straw be returned to the soil there is enough potassium present in the surface foot of the Juab County farm to last for the production of a 25 bushel crop of wheat every other year for 6186 years. In other words, the potassium is sufficient for indefinite periods of time provided the farmer so cultivates his land as to render the plant food available. It is practically certain that the potassium question on the dry farms of the State is one of liberation of this plant food from the inexhaustible

supply in soil and not one of addition. There are two practical ways by which plant food may be liberated from the locked up compounds in the soil. First, by practicing the system of summer fallow and thus allowing the soil to enter the winter in a porous open condition. The alternate freezing and thawing tends to liberate the plant food from its insoluble condition. Second, the addition of organic matter to the soil and its resultant decay with the production of organic acids converts the potassium into an available form.

In the Juab County soil the potassium decreases with depth, there being only 56 per cent as much total potassium in the ninth foot as compared with that in the first. This may possibly be explained by the reported discovery of potassium in the hills to the east of the valley.

The potassium content in the soils of the San Juan, Tooele, and Washington County farms is also decreased with depth, while that of the Iron County soil is practically constant with depth.

6. The Nitrogen Content.

Nitrogen is the most expensive of all the plant foods having a commercial value. Four-fifths of the air is nitrogen, but it occurs in a free or elemental form which is unavailable for the use of the higher plants. The results obtained for the nitrogen content of the dry farm soils is recorded in the following table:

TABLE III.

County	Juab.	San Juan.	Sevier.	Iron.	Tooele.	Washington.
Per cent Nitrogen..	0.116	0.065	0.089	0.057	0.07	0.091
Pounds per two million pounds of soil.	2,320	1,300	1,780	1,140	1,540	1,820

The nitrogen content of these soils in the virgin condition is thus seen to be very low as is characteristic of the soils

of arid America. The soil of the Juab farm is highest, there being 2320 pounds of nitrogen in the first two million pounds of soil, while Iron County soil contains the least or only 1140 pounds of nitrogen per two million of soil. The nitrogen content uniformly decreases with depth. It takes 48 pounds of nitrogen to produce a 25 bushel crop of wheat, 12.5 pounds for the straw and 35.5 pounds for the grain. Assuming that all of the straw is returned to the soil, there is only nitrogen enough in the plowed surface of the soil to last for the production of a 25 bushel wheat crop for only 180 years. This comparative method of study clearly indicates that on the dry farms of this State that nitrogen is the limiting element of plant food. Of course the wheat plant in its search for moisture feeds on the dry farm to greater depths than the plowed surface. These results clearly bring to mind, however, the necessity of utilizing all the waste material of the farm. Methods must be devised for the utilization of the straw stacks which are all too commonly burned on the dry farm.

The question of the importance of the nitrogen question on the dry farms has previously been discussed* for one section of the State and it is hoped that additional data will be presented for the other three great dry farming sections in the near future.

7. The Organic Matter of the Dry Farm Soils.

The humus content as determined by the methods of the Association of Official Agricultural Chemists was obtained on all the samples. This is a rough measure of the organic matter of the soil although it should be clearly kept in mind that the results are probably higher than the correct results because "humus" obtained by the official method always contains clay or finely divided soil, which loses water by hydration on heating. In these soils also the "clay" undoubtedly contains some calcium carbonate which would

* Stewart, Bulletin No. 109, Utah Experiment Station.

also lose carbon dioxide when heated. The humus results are indicated in the following table.

TABLE IV.

Humus Content in the Dry Farming Soils.

County	Juab.	San Juan.	Sevier.	Iron.	Tooele.	Washington.
Humus, per cent...	1.54	1.49	1.45	1.09	1.16	1.63

These results indicate that the organic matter as represented by the humum content is low, indicating anew the marked deficiency of organic matter in our arid soils. In these high carbonate soils the results obtained on the ignition of the soil the so-called "volatile matter" is no indication whatever of the organic matter of the soil.

8. The Limestone Content.

From the amount of calcium oxide, magnesia and carbon dioxide it is possible to get a fairly accurate idea of the limestone content of the soil under consideration. The results obtained for these substances in the arid soils together with pounds of limestone per 2,000,000 pounds of soil as calculated from the carbon dioxide content are reported in the following table.

TABLE V.

Calcium Oxide, Magnesia, Carbon Dioxide, and Limestone, in Dry Farm Soils.

County	Juab.	San Juan.	Sevier.	Iron.	Tooele.	Washington.
Calcium Oxide......	4.27	0.56	1.34	18.97	2.15	3.01
Magnesia	1.82	0.75	0.42	2.24	0.47	1.06
Carbon Dioxide.....	2.16	0.20	0.62	18.55	1.01	1.96
Limestone per two million pounds of soil	49,100	4,540	14,074	420,000	229,550	44,500

These results indicate quite clearly that with all of the dry farms in the Great Basin the soils are abundantly sup-

plied with limestone. The San Juan farm, located in Colorado drainage district presents an entirely different aspect. The first foot soil contains scarcely any limestone, yet the subsoil in the sixth foot is abundantly supplied with it in spots as represented by Lab. No. 29088, while in other parts of the subsoil there is no more than in the surface. In the soil of all the other farms the limestone content is higher throughout, the Sevier County farm being the only one in which there is any possibility in the distant future of being deficient in limestone. In the plowed surface soil of the Juab County farm for example, there is approximately 25 tons of limestone present, while in the Iron County farm there is 210 tons of limestone. The dry farming soils of Utah are distinctly not acid in nature.

9. Conclusions.

A study of the results reported in this bulletin clearly indicate that the soil fertility problem on the dry farms is clearly one of the addition of organic matter containing nitrogen to the soil for the purpose of liberation of the plant food. With the exception of the San Juan County section there is no possibility of the soil becoming acid in nature. The soils are all abundantly supplied with sufficient potassium for wheat production, which will undoubtedly be the chief crop produced on the dry farms. The soils are well supplied with phosphorus and it is not probable that the addition of this element would be profitable in the immediate future. Further, investigation should be carried on regarding the nitrogen and humus content of our dry farm soils. And in the meantime every occasion should be taken to plow under the stubble and to make better utilization of the straw stacks on the farm.

TABLE VI.

Physical Composition of Soils of the Experimental Dry Farms.
(Results Expressed as Per Cent of Dry Soil.)

JUAB COUNTY FARM.

Depth in feet..	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th
Lab. Nos........	29005	29606 -07-09	29014	29015 -17	29019	29026	29030	29032	29040	29049
Coarse matter...	9.59	5.29	8.94	4.43	5.85	2.20	3.64	3.93	4.54	5.38
Fine matter....	90.41	94.71	91.06	95.57	94.15	97.80	96.36	96.07	95.46	94.62
Medium sand...	8.93	8.99	8.73	11.36	15.69	8.98	16.28	12.60	23.57	15.48
Fine sand.......	20.05	16.48	12.38	18.87	19.48	27.40	25.00	22.52	26.09	21.45
Coarse silt......	21.97	19.95	22.53	19.06	23.88	22.27	21.88	21.91	19.25	18.63
Medium silt.....	15.23	16.78	17.53	17.25	15.43	13.51	13.73	17.03	10.04	15.77
Fine silt........	13.25	14.88	14.47	8.93	8.01	7.11	8.68	9.74	6.56	11.71
Fine clay.......	15.73	16.68	18.62	20.68	12.41	10.03	12.19	13.29	20.95	13.36
Real Sp. Gr.....	2.62	2.67	2.52	2.62	2.62	2.86	2.61	2.64	2.61	2.63
Apparent Sp. Gr.	1.37	1.46	1.42	1.12	1.41	1.43	1.46	1.41	1.48	1.44
Water, Sol. mat.	0.09	0.702	0.02	0.04	0.11	0.07	0.11	0.13	0.05	0.20

SAN JUAN COUNTY FARM.

Depth in feet......	1st	2d	3d	4th	6th	7th	8th	9th
Lab. Nos.	29054 -55	29059	29063	29069	29084 -88	29089 -90-92	29095	29097
Coarse matter......	1.05	1.30	....	0.82	3.75	2.83	1.65	0.47
Fine matter........	98.95	98.70	All Fine	99.18	96.25	97.17	98.35	99.53
Medium sand	11.07	13.54	12.45	13.80	13.31	18.34	9.57	10.19
Fine sand..........	50.21	45.21	46.10	45.38	32.39	36.43	40.48	42.29
Coarse silt.........	12.80	11.40	16.78	13.58	16.50	13.87	16.55	15.71
Medium silt........	8.18	7.84	9.22	9.72	14.37	19.03	9.46	8.55
Fine silt...........	5.47	6.27	5.26	5.51	9.14	9.19	7.39	6.41
Fine clay..........	9.77	11.10	5.64	9.92	12.02	14.94	12.33	13.84
Real Sp. Gr........	2.58	2.63	2.63	2.59	2.63	2.57	2.56	2.58
Apparent Sp. Gr....	1.41	1.39	1.39	1.40	1.35	1.43	1.35	1.36
Water, Sol. mat....	0.09	0.10	0.008	0.02	0.08	0.09	0.13	0.13

TABLE VII.

Physical Composition of the Soils of the Experimental Dry Farms.
(Results Expressed as Per Cent of Dry Soil.)

IRON COUNTY FARM.

Depth in feet	1st	2d	3d	4th	5th
Lab. Nos.	28688-89-90	28694-96	28702-05	28708-10	28752
Coarse matter	1.54	3.89	3.18	4.21	3.32
Fine matter	98.46	96.11	96.82	95.79	96.68
Medium sand	13.20	8.66	11.63	16.35	22.04
Fine sand	17.77	13.03	12.85	18.46	17.34
Coarse silt	22.75	23.65	19.98	18.07	18.36
Medium silt	19.33	21.25	21.66	18.55	16.91
Fine silt	10.60	13.86	14.69	12.08	11.36
Fine clay	10.96	15.03	13.79	11.11	10.83
Real Sp. Gr.	2.64	2.70	2.63	2.66	2.67
Apparent Sp. Gr.	1.39	1.37	1.38	1.43	1.45
Water, Sol. material	0.48	0.22	0.31	0.29	0.40

SEVIER COUNTY FARM.

Depth in feet	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th
Lab. Nos.	28835	28836-39-40	28843-40	28851-52	28857-61	28862	28871	28878	28881	28886
Coarse matter	20.58	29.61	28.94	36.34	37.08	25.24	30.07	29.44	34.67	27.21
Fine matter	79.42	60.39	71.05	63.66	62.92	74.76	69.93	70.56	65.33	72.79
Medium sand	26.29	37.52	25.28	33.35	37.69	26.87	27.97	28.41	30.40	34.08
Fine sand	24.63	20.04	28.07	23.29	22.99	25.82	24.07	26.32	26.13	25.34
Coarse silt	17.12	10.75	13.66	9.42	14.07	8.00	15.21	16.71	14.57	13.61
Medium silt	10.07	7.56	10.43	10.42	8.57	7.26	10.47	11.30	9.89	10.25
Fine silt	7.69	6.00	5.98	11.25	5.78	2.35	7.74	4.79	4.38	6.62
Fine clay	10.14	13.49	11.11	8.81	7.57	19.95	13.79	8.79	9.65	8.62
Real Sp. Gr.	2.67	2.69	2.68	2.69	2.72	2.65	2.65	2.68	2.64	2.67
Apparent Sp. Gr.	1.40	1.41	1.37	1.37	1.44	1.38	1.39	1.43	1.39	1.38
Water, Sol. mat.	0.15	0.076	0.06	0.12	0.09	0.19	0.10	0.13	0.10	0.20

TOOELE COUNTY FARM.

Depth in feet	1st	2d	3d	4th	5th	6th	7th	8th	9th
Lab. Nos.	28981	28982-85	28989	28992	28996	28999	29001	29003	29004
Coarse matter	5.34	5.56	13.55	6.76	9.25	3.24	2.42	3.01	3.23
Fine matter	94.66	94.44	86.45	93.25	90.75	96.76	97.58	96.99	96.77
Medium sand	11.61	11.23	11.44	9.96	9.42	7.65	10.88	....	9.63
Fine sand	32.62	30.27	29.86	28.52	29.63	26.12	26.28	30.06	36.02
Coarse silt	20.50	22.25	19.41	19.57	23.20	20.53	21.78	21.84	21.25
Medium silt	13.86	14.69	14.31	18.27	11.63	14.62	12.97	14.32	13.54
Fine silt	61.70	9.12	10.00	5.83	10.19	11.84	10.99	8.93	7.13
Fine clay	9.47	11.71	19.71	15.28	13.66	15.94	13.72	12.24	9.91
Real Sp. Gr.	2.61	2.61	2.58	2.67	2.65	2.70	2.73	2.68	2.67
Apparent Sp. Gr.	1.40	1.38	1.37	1.36	1.37	1.36	1.35	1.35	1.37
Water, Sol. mat.	0.33	0.06	0.16	0.13	0.20	0.42	0.40	0.29	0.31

TABLE VII—Continued.

WASHINGTON COUNTY FARM.

Depth in feet	1st	2d	3d	4th	5th	6th	7th	8th	9th
Lab. Nos	28356-59	28362	28370-74	28379	28384-85	28389	28396	28400	28404
Coarse matter	11.71	12.02	11.28	15.90	17.63	29.14	13.90	22.05	30.94
Fine matter	88.29	87.98	88.72	84.10	82.37	70.86	86.10	77.95	69.06
Medium sand	28.26	18.25	29.37	25.94	26.83	28.52	34.56	32.54	35.71
Fine sand	29.34	27.64	26.07	28.19	28.41	32.11	26.34	27.48	27.45
Coarse silt	14.67	10.71	11.26	11.95	14.44	10.96	10.91	10.58	10.78
Medium silt	8.91	11.81	11.31	10.42	7.92	9.51	8.14	10.32	7.78
Fine silt	6.36	7.60	5.89	7.14	6.91	6.23	7.05	5.50	6.46
Fine clay	8.19	12.63	10.40	12.49	9.71	7.79	10.41	10.13	8.63
Real Sp. Gr	2.67	2.61	2.63	2.67	2.62	2.62	2.63	2.62	2.64
Apparent Sp. Gr	1.46	1.43	1.42	1.41	1.42	1.41	1.42	1.37	1.41
Water, Sol. mat	0.15	0.41	0.11	0.02	0.10	0.06	0.04	0.02	0.003

TABLE IX.

Fertility in Soil of Juab County Experimental Dry Farm.

(Results Expressed as Per Cent of Dry Soil.)

Depth in Feet	1st	3d	4th	9th
Lab. Nos	29005	29014	29017	29040
Insoluble Residue	73.12	62.10	62.00	65.69
Potash, K_2O	1.31	0.91	0.67	0.70
Soda, Na_2O	0.14	0.18	0.52	0.68
Lime, CaO	4.27	11.05	12.34	11.83
Magnesia, MgO	1.82	1.80	2.66	2.93
Sulphuric Acid, SO_3	0.13	0.12	0.17	0.07
Oxide of Iron, Fe_2O_3	3.92	3.61	2.26	2.36
Alumina, Al_2O_3	6.33	6.43	5.05	3.36
Phosphoric Acid, P_2O_5	0.419	0.471	0.356	0.264
Carbon Dioxide, CO_2	2.16	9.10	10.74	10.09
Volatile Matter	5.31	4.35	2.79	2.57
Total	99.28	100.24	99.72	100.60
Humus*	1.54	1.99	1.56	1.15
Nitrogen	0.116	0.103	0.040	0.050
Total Phosphorus	0.191	0.219	0.181	0.112
Total Potassium	2.32	1.75	1.48	1.30

* By the official method. Probably too high, since it may include water of hydration in suspended clay.

TABLE X.

Fertility in Soil of San Juan County Experimental Farm.

(Results Expressed as Per Cent of Dry Soil.)

Depth in Feet	1st	6th	7th	9th
Lab. Nos.	29054	29088	29089	29090
Insoluble Residue	88.25	54.74	68.96	86.87
Potash, K_2O	0.83	0.52	0.27	0.54
Soda, Na_2O	0.36	0.13	0.41	0.70
Lime, CaO	0.56	19.04	11.46	0.79
Magnesia, MgO	0.75	0.76	0.45	0.81
Sulphuric Acid, SO_3	0.05	0.15	0.12	0.10
Oxide of Iron, Fe_2O_3	3.10	4.69	2.01	3.02
Alumina, Al_2O_3	3.06	2.98	3.69	5.24
Phosphoric Acid, P_2O_5	0.24	0.29	0.08	0.10
Carbon Dioxide, CO_2	0.20	14.58	9.03	0.14
Volatile Matter	3.02	2.64	3.60	1.62
Total	100.12	100.52	100.08	99.93
Humus	1.49	0.61	0.65	1.35
Nitrogen	0.065	0.015	0.040	0.018

TABLE XI.

Chemical Composition of Soil From Sevier County Arid Farm.

(Results as Per Cent of Dry Soil.)

Depth in Feet	1st	4th
Lab. Nos.	28835	28851
Insoluble Residue	80.78	75.76
Potash, K_2O	0.83	0.70
Soda, Na_2O	0.34	0.42
Lime, CaO	1.34	4.63
Magnesia, MgO	0.42	1.40
Sulphuric Acid, SO_3	0.06	0.13
Oxide of Iron, Fe_2O_3	5.42	5.23
Alumina, Al_2O_3	5.74	0.14
Phosphoric Acid, P_2O_5	0.26	0.14
Carbon Dioxide, CO_2	0.62	2.79
Volatile Matter	4.14	3.64
Total	....	....
Humus	1.45	0.85
Nitrogen	0.089	0.037

TABLE XII.

Fertility in Soils of Iron County Experimental Dry Farm.
(Results Expressed as Per Cent of Dry Soil.)

Depth in Feet	1st	1st	4th	9th
Lab. Nos	28688	28689	28710	28752
Insoluble Residue	52.14	51.19	52.38	46.47
Potash, K_2O	0.55	0.56	0.45	0.42
Soda, Na_2O	0.44	0.18	0.52	0.42
Lime, CaO	18.97	17.84	17.83	20.22
Magnesia, MgO	2.24	1.22	2.08	0.75
Sulphuric Acid, SO_3	0.11	0.13	0.11	0.11
Oxide of Iron, Fe_2O_3	2.80	2.46	2.50	2.55
Alumina, Al_2O_3	2.29	3.85	4.36	6.62
Phosphoric Acid, P_2O_5	0.23	0.20	0.24	0.19
Carbon Dioxide, CO_2	18.55	17.95	15.12	20.08
Volatile Matter	3.35	5.28	4.42	2.93
Total	101.82	100.87	100.01	100.76
Humus	1.09	1.55	0.50	1.31
Nitrogen	0.057	0.086	0.040	0.025

TABLE XIII.

Fertility in Soil of Tooele County Experimental Dry Farm.

Depth in Feet	1st	4th
Lab. Nos	28981	28992
Insoluble Residue	80.13	78.49
Potash, K_2O	0.95	0.80
Soda, Na_2O	0.41	0.51
Lime, CaO	2.15	3.21
Magnesia, MgO	0.47	0.66
Sulphuric Acid, SO_3	0.06	0.05
Oxide of Iron, Fe_2O_3	4.49	4.28
Alumina, Al_2O_3	5.60	6.47
Phosphoric Acid, P_2O_5	0.31	0.12
Carbon Dioxide, CO_2	1.01	2.04
Volatile Matter	4.38	4.19
Total	99.97	100.82
Humus	1.16	0.77
Nitrogen	0.007	0.040

TABLE XIV.

Fertility in Soil of Washington County Experimental Dry Farm, Enterprise, Utah.

(Results Expressed as Per Cent of Dry Soil.)

Depth in Feet	1st	4th	8th
Lab. Nos	28359	28379	28340
Insoluble Residue	81.74	78.20	71.96
Potash, K_2O	0.87	0.74	0.50
Soda, Na_2O	0.23	0.30	0.28
Lime, CaO	3.01	6.00	9.71
Magnesia, MgO	1.06	0.59	0.65
Sulphuric Acid, SO_3	0.10	0.08	0.11
Oxide of Iron, Fe_2O_3	3.14	2.79	2.92
Alumina, Al_2O_3	4.19	4.43	3.85
Phosphoric Acid, P_2O_5	0.24	0.23	0.23
Carbon Dioxide, CO_2	1.96	3.95	7.14
Volatile Matter	3.83	3.46	2.95
Total	100.37	100.77	100.21
Humus	1.63	1.69	1.55
Nitrogen	0.091	0.10	0.025

TABLE XV.

Nitrogen, Humus and Carbon Dioxide in Soils.

(Results Expressed as Per Cent of Dry Soil.)

JUAB COUNTY FARM.

Depth in feet		2d	2d	4th	5th	6th	7th	8th	10th
Lab. Nos	29006	29007	29009	29015	29019	29026	29030	29032	29049
Humus	1.71	1.86	2.43	1.80	1.63	1.50	1.72	1.21	1.62
Nitrogen	0.054	0.084	0.064	0.047	0.028	0.026	0.030	0.032	0.029
Carbon Dioxide	3.79	9.18	5.82	11.33	12.41	11.12	11.62	8.64	7.88

SAN JUAN COUNTY FARM.

Depth in feet	1st	2d	3d	4th	6th	8th	9th
Lab. Nos	29055	29059	29063	29069	29084	29095	29097
Humus	1.62	1.84	1.08	1.58	1.78	1.79	1.32
Nitrogen	0.070	0.060	0.042	0.026	0.023	0.018	0.021
Carbon Dioxide	0.36	0.08	0.38	0.11	0.015	....	1.86

SEVIER COUNTY FARM.

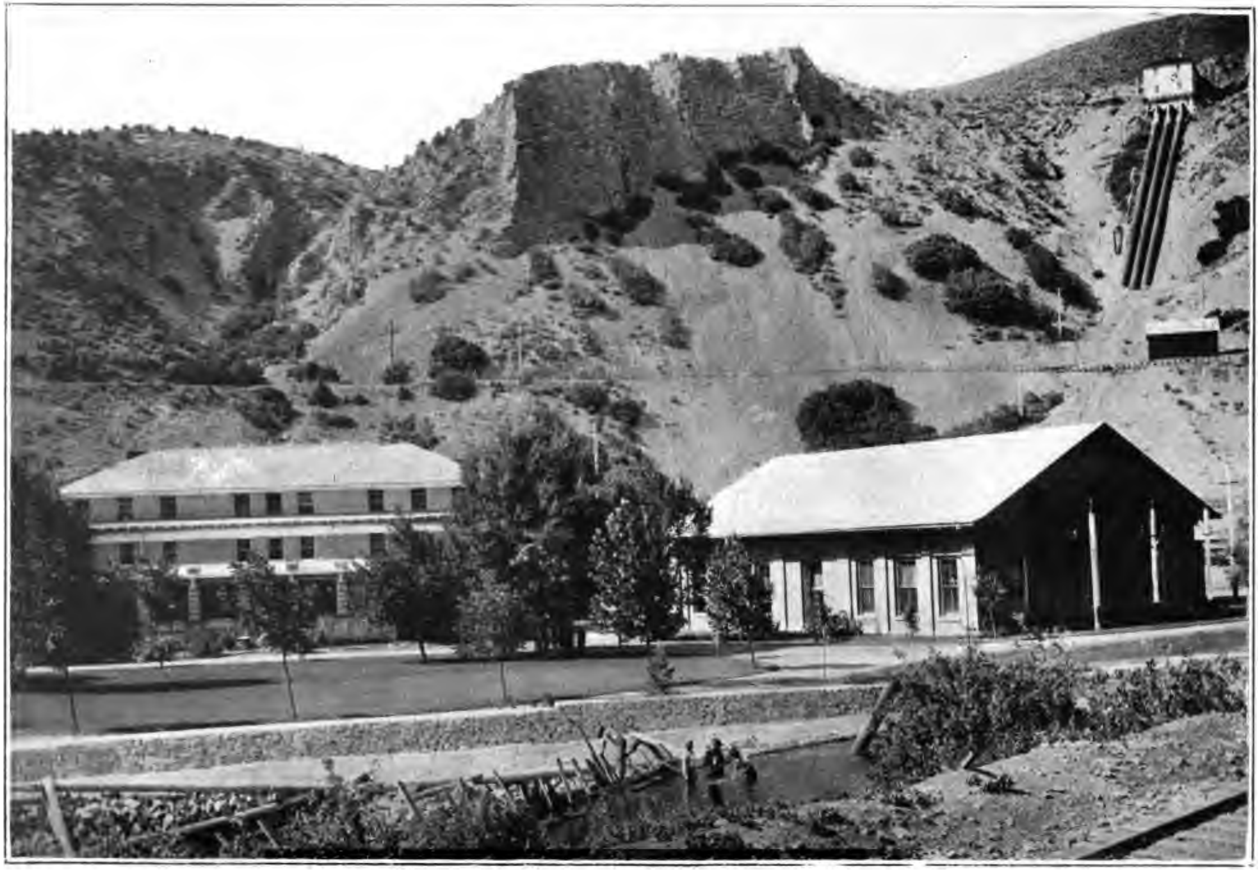
Depth in feet..	1st	2d	3d	4th	5th	6th	7th	8th	9th	10th
Lab. Nos........	28835	28836 -39-40	28843 -44	28851 -52	28857 -61	28862	28871	28878	28881	28886
Humus	....	....	....	....	....	....	....	....	....	....
Nitrogen	0.084	0.046	0.044	0.037	0.033	0.029	0.025	0.016	0.16	0.019
Carbon Dioxide.	0.62	0.08	1.58	1.98	0.89	0.47	0.50	0.47	0.46	0.38

IRON COUNTY FARM.

Depth in feet.............	1st	2d	3d	3d	4th	4th
Lab. Nos..................	28690	28694	28696	28702	28705	28708
Humus	1.48	2.20	2.21	1.68	2.58	1.50
Nitrogen	0.092	0.058	0.062	0.041	0.052	0.040
Carbon Dioxide...........	15.77	18.80	18.23	16.28	16.99	15.76

WASHINGTON COUNTY FARM.

Depth in feet.............	3d	5th	5th	6th	7th	9th
Lab. Nos..................	28374	28384	28385	28389	28396	28404
Humus	1.65	0.81	1.74	1.51	1.60	1.41
Nitrogen	0.047	0.032	0.042	0.030	0.034	0.032
Carbon Dioxide...........	3.04	3.22	5.02	3.06	8.96	4.60



Telluride Power Company's Plant at Mouth of Provo Canyon.

WATER

The report of the State Conservation Commission for the year 1909 contains what were then considered some rather startling statements concerning the water supply of our State and the relatively large amount of water that ran to waste. In that report it was stated that there were in Utah, Tooele, Salt Lake, Davis and Weber counties approximately 125,000 acres of land that could be irrigated from the waste or flood waters of the two principal streams—Provo and Weber rivers.

It was shown from the reports of the Geological Survey that the flood or waste waters from the Provo and Weber rivers in the year 1904, which was taken as an average of the preceding twenty-two years, was 937,300 acre feet. Not only are there 125,000 acres of land to which the waters of these streams could be taken, but an investigation has shown that there are more than 650,000 acres in Utah, Tooele and Salt Lake counties alone to which the waters of Provo and Weber rivers could be applied. The Reclamation Service has determined, through some tests made during the period of the last six years, that one and one-half acre feet of water per acre is sufficient to bring to maturity most, if not all, farm crops grown in Utah county. If this be true, and similar conditions must exist to greater or less extent in other localities, then there are flood or waste waters enough in the Provo and Weber river systems to place under irrigation practically all of the arid lands in Utah, Tooele and Salt Lake counties.

What is true with respect to waste and flood waters in these two river systems, is true more or less generally throughout the State. It would appear, therefore, that there is ample room for a general awakening on the part of the public with regard to the possibilities of conserving and placing to a beneficial use on our arid lands this enormous

GRAND RIVER, NEAR MOAB, UTAH.
The old ferry, now superseded by a high bridge. Showing immense waste of water that could be used to develop power.

amount of waste water, and the duty of the State to point out, direct, and urge policies of conservation is clear.

It is, perhaps, not generally realized, but is none the less true, that within a radius of fifty miles of Salt Lake City there are irrigable arid lands in an amount equal to more than half of the acreage now under irrigation in the entire State. A number of reasons can be assigned for this apparent oversight on the part of the public and investing capital, chief of which is, perhaps, the high water costs, due to the distance of the lands from vantage points for storage reservoirs and to the natural physical difficulties to be encountered in the construction of a system to irrigate those lands. It is estimated that the water costs on these lands would range from $75.00 to $150.00. There are large areas in the State, probably more than five million acres, where waters can be applied to lands for a cost of $10.00 to $50.00 per acre, much of which land has climate and soil conditions equal to the lands lying around Salt Lake City, but lacks, of course, transportation facilities and opportunity for market which would make these nearer lands a profitable investment at an increased cost. Naturally, however, people generally seek the cheap lands first. There exists, perhaps, more of an inclination to investigate and, if possible, place under irrigation these lands than is generally known.

The United States government has almost completed the Strawberry project, which will bring under irrigation some 60,000 acres in Utah county. This is the only government project in this State, and, of course, as against our 12,000,000 arid acres which need water, does not make much impression, but it is a step in the right direction. In connection with this project the Commission has made some investigations from which it would appear that there will be more water than can be economically used under the system as at present outlined. Any surplus from the project could be used with great benefit to the lands of Juab county, which can be reached from this source. South of what is known as Santa-

quin Ridge and north of Levan Ridge there are more than 70,000 acres of arid land which could be reached with water from the Strawberry system. If a portion of this water could be taken into these lands, say 20 acres of water to each eighty-acre farm, this would make possible the making of a great many homes in that section of the State. It is a section which is advantageously located so far as transportation facilities are concerned. It is hoped that this matter will receive the careful consideration of the proper authorities, and, if feasible and practicable, as it appears to be, that steps will be taken to secure any surplus water from the Strawberry propect for these lands.

The State of Utah has undertaken the work of building irrigation projects to redeem its arid lands and there are now completed, or in progress of completion, the following systems:

Piute, 22,000 acres; Hatchtown, 8,000 acres.

There are also a number of private and Carey-act projects under way which, when completed, will provide water for a large acreaage, a few of which are mentioned here.

Carey Act Projects.

	Total Acreage.	Maximum Sellıng Price of Land and Water Per Acre.
Delta Land & Water Co.	43,000	$ 50
Woodside Irrigation Co.	7,000	150
Buckhorn Land Co.	12,000	150
Myton Bench Project.	35,000	40–50
Virgin Valley Reclamation Co.	14,000	200
Spanish Valley Water & Land Co.	5,000	250
Neponset Land & Irrigation Co.	5,000	35
Green River Carey Act Project.	150,000	150
Total	221,000	

Most of the land of the Delta Land & Water Company has been sold. The Neponset Land & Irrigation Company has private lands now under cultivation.

SPANISH VALLEY CAREY ACT PROJECT.

Five thousand acres net of fertile lands, with a very warm climate in growing season, making it possible to raise corn, will be reclaimed by means of storage of water now wasted in the winter and in floods in the spring and fall.

Private Projects.

	Total Acreage.	Maximum Selling Price of Land and Water Per Acre.
Provo Reservoir Company	10,700	$ 75–80
Utah Lake Irrigation Co	20,000	35–60
Newcastle Reclamation Co	25,000	35–70
Davis and Weber Counties	24,000	90–175
Ogden River Reservoir Co	20,000	...
Mosida Irrigation Project	9,500	150
Green River Irrigation District	4,384	50
Sevier River Land & Water Co	50,000	65
Total	163,084	

Utah Lake Irrigation Company.

This company proposes to irrigate, by means of a pumping system, about 20,000 acres of land in the north end of Utah county and the south end of Salt Lake county. The first unit of this project to irrigate about 3,000 acres is now nearing completion. This is a mode of irrigation which should be encouraged, inasmuch as by this means waters which would otherwise run to waste can be utilized. Seepage waters reaching the lowlands and waters from the lakes can by this means be placed upon the higher lands in the immediate vicinity. Wherever it is practicable, however, it will be found more profitable in the long run, and much more preferable, to irrigate by means of the gravity system.

Utah Conservation Company.

In June, 1910, a few leading citizens conferred with the Governor as chairman of the Conservation Commission relative to the matter of conserving the waters of Provo and Weber rivers. The Governor called together a number of the prominent business men of the State for the purpose of discussing ways and means to this end. A committee was appointed to make investigation and report. This committee reported that it appeared to be entirely practicable to store

much of the waste waters of these systems and to conduct them to lands near Salt Lake City at reasonable cost. A company was organized with a capital of $100,000 to further prosecute these investigations and to make provision for the conserving of these waste waters. This company, known as the Utah Conservation Company, has for its object and purpose the conserving of the waters of these streams and putting them on the lands in Weber, Davis, Salt Lake, Tooele and Utah counties, and as opportunity will permit, to extend operations to other sections and localities in the State. The company is composed of the leading merchants, bankers, capitalists and business men of Salt Lake City, Ogden and other sections of the State. These gentlemen will provide the necessary capital to carry these projects to successful completion. The proposed projects of this company were gone over by Mr. F. H. Newell, director of the Reclamation Service, who, so far as his investigations extended, heartily approved the plans, and expressed the opinion that the State would be materially benefited by such investigations and developments.

From its investigation along this line the Commission feels that some action should be taken to protect certain localities in their water rights. In other words, that the State should provide some means by which the Governor or other officer might be authorized, on investigation and presentation of facts, to warrant such action, to withdraw waters for the benefit of the lands under the particular system in order that it might be preserved for irrigation purposes for those particular lands.

There are some localities in the State where there is a shortage of water, particularly late water, and where the waste waters of the flood season, if stored, would furnish an ample supply, but where on account of the distance from vantage points for reservoirs and physical difficulties in the way of the construction of a system for storing waters, the cost is so great that the farmers of the locality cannot undertake the work of constructing a system themselves. The

A STORAGE SITE ON PRICE RIVER, NEAR WOODSIDE, EMERY COUNTY.

125,000 to 300,000 acre-feet of flood waters pass here annually. There is more water than land, only about 7000 acres net being available in Price River Valley, but 10,000 to 15,000 can be obtained by crossing Green River Valley, reaching lands too high to be served by Green River.

work of financing such projects, of getting outside capital interested in such work, requires usually some considerable time. If, in such cases, some officer of the State could withdraw waters necessary for the particular tract from appropriation for power or by private parties for speculative purposes, and hold the same for a reasonable time to give to the people of the locality opportunity to secure financial aid and undertake the construction of such system as may be necessary to supply the water necessary for the particular locality.

Great care should be exercised in such cases to see that no waters are withdrawn from appropriation and held for a particular locality to the injury of other sections or communities entitled to them, and where, perhaps, more energetic efforts to place them to beneficial use are made.

The inroads being made upon the waters of our streams by power developments are very serious, and while nothing should be done to prevent the use of the waters of our streams for power purposes so long as their use for purposes of irrigation are not destroyed, yet action should be taken to prevent the appropriation of water for power when such appropriation will effectually destroy its use for irrigation. Thousands of acres of water are being used in this manner every year, and as time goes on, use for power will increase and conflicts will become more acute between the two interests, which, if taken in time, may be averted and the two interests harmonized in such a way as to result in the best good and greatest development of our agricultural resources, which is the foundation of the growth and development of our State..

There are many localities in the State where, if the State credit could be employed for the benefit of the community to aid in increasing the water supply, a most helpful growth would be stimulated, and which cannot come unless assistance and credit extending over a long period is given.

GROUND WATER.

JUAB, MILLARD, IRON COUNTIES.

Rush Valley.

Francis Webster, near Enoch, has a flowing well two inches in diameter and 153 feet deep.

In Cedar bottoms, several miles west of Webster's well, Mr. McConnell has a flowing well.

Mr. A. Thornley, a half mile north of Eight-mile Springs, has four flowing.

Mr. Williams has five flows near Mud Springs. There is another flow near Kanarraville. There are several good wells near Ward's ranch, also near Enoch.

It is thought that hundreds of acres could be irrigated by means of pumped water in Rush and Parowan Valley.

In Parowan Valley, at Lowder, fourteen wells irrigate more than 100 acres, and at Culver twelve wells yield 1½ second feet..

Juab Valley.

Several flowing wells in North Basin.

Taylor, one flowing well, 200 gallons per minute, South Basin.

Dug wells in Fields, below Levan.

Flowing wells at Starr.

"Much of the water falling on the upper gravelly deposits reappears in the low central axis of valley, where it cannot be used. It is thought that this could be recovered in places where it could be used by pumping."—Water Supply 277, p. 74.

Round Valley.

Scipio—Ground water at 10-100 feet. No flows.

Little Valley.

Twelve flows along low swampy land.

Sage Dog, Fernow Valleys.

No well. Ground water doubtful.

PROPOSED DAM SITE, SPANISH VALLEY CAREY ACT PROJECT.
Structure to be of rock-fill type, faced on water side with reinforced concrete. Ten miles southeast of Moab, Grand County, Utah. Storage of flood waters now wasted will make it possible to reclaim 5,000 acres now desert.

Tintic Valley.

Two flowing wells; poor. One open well.

Jerico.

Dug wells, 50-100 feet deep.

Tintic Junction.

Two dug wells.

It is likely that water could be obtained in the lower part of the valley, at medium depth, but that in the higher parts, where it would be useful for irrigation, it is at too great depth to make its recovery practical.

Pahvant Valley.

Ground water readily obtained. As yet no flows have been obtained and conditions do not seem favorable for artesian pressure.

Lower Beaver Valley.

On Beaver Bottoms wells are readily obtained, but the water is of poor quality, being salty. The railroad well at Goss, 1,775 feet deep, contains much water; 75 gallons per minute was pumped for one year, but water did not improve.

Neels.

1,998 feet deep; water at 9 horizons; six-inch casing for one, 425 feet; one 300 gallons per minute for 24 hours.

With Sillett pump 2,000 gallons per minute were obtained. Water all salty. (Abandoned.)

Another deep well at Clear Lake Station; also salty (Abandoned.)

Swan Lake farm wells, six miles west of Clear Lake. There is an old flowing well, 500 feet deep; 500 parts per 1,000,000 of clorine.

Old River Bed and Cherry Creek Region.

It is thought that wells yielding good water could be probably got at moderate depths, though water at present is very scarce.

Sevier Desert.

At Lynn and Leamington the ground water at about 100 feet below the upland surface.

Lynn.

Railroad well, 225 feet deep (finished 1905); pumped 108 gallons per minute for eleven hours.

Leamington.

A group of dug wells, 20-25 feet, yield plenty for domestic use.

One and a half miles southeast of Leamington good well, 45 feet deep. No wells further south.

Near Deseret, Oasis, Hinckley, Burtner, Abraham, several hundred wells, between 100 and 200 and even 300 feet deep. In these wells water is found at only a few feet below the surface, and in a great number the water rises above the surface.

Southwest of Weston's well, Deseret, water just found at 12 feet; drilled to 240 feet and got a flow.

Wah Wah Valley.

Conditions not favorable for finding ground water.

White Valley.

No wells, but quite probably some could be found, as conditions seem favorable.

Snake Valley.

Burbank, Harrison, Pleasant Valley, Callao—Water (sometimes flow) is readily obtained.

SPANISH VALLEY CAREY ACT PROJECT.

Part of watershed, above 10,000 feet in elevation, on La Sal Mountains. These mountains are 13,000 feet high and heavily timbered with pine. These mountains are embraced within the La Sal National Forest Reserve. Southeast of Moab and on boundary between Grand and San Juan Counties.

RIVER SYSTEMS OF STATE.

River—Measured at.	Run-off Acre Ft.	Run-off Acre Ft. Total.	Years in Average.
Bear—Preston	1,019,666	....	6
Logan—Logan	249,344	....	9
Blacksmith Fork—Hyrum	155,156	....	8
Other Sources	134,868	....	..
Bear—Collinston	....	1,559,034	10
Weber—Plain City	....	883,900	5
Big Cottonwood—Salt Lake City	62,080	....	9
Little Cottonwood	11,900	....	1
City Creek	13,260	....	10
Parleys Creek	20,070	....	11
Mill Creek	13,000	....	12
Emigration	2,600	....	6
Total	....	104,910	..
Utah Lake.			
Summit Creek—Santaquin	12,500	....	1
Spanish Fork—Spanish Fork	132,750	....	5
Hobble Creek—Springville	54,000	....	4
Provo—Mouth of Canyon	319,830	....	7
American Fork—American Fork	38,480	....	2
Total	....	557,560	..
Sevier—Gunnison	232,320	....	8
San Pitch—Gunnison	33,450	....	4
Beaver Creek—Minersville	29,450	....	2
Total	....	295,220	..
Colorado.			
Green River—Green River	6,400,710	....	7
Grand	....	....	..
San Juan	....	....	..
Virgin	....	....	..
Total Colorado—Yuma, Ariz.	18,405.000	....	..
		18,405,000	..
Grand Total		21,805,624	

WELLS OF THE STATE.

County	Number of Wells.			Number of Pumping Plants.	Capacity of Wells.			Irrigated. Number Acres		
	Flow.	Pump.	Total.		Flow.	Pump.	Total.	Flow.	Pump.	Total.
Box Elder.......	77	22	99	23	1,768	3,964	5,732	222	281	503
Cache	33	..	33	..	734	....	734	45	...	45
Davis	242	..	242	..	9,551	....	9,551	835	...	835
Emery	....	1	1	11	....	480	480	....	6	6
Iron	86	..	86	..	2,137	....	2,137	....	...	....
Juab	6	..	6	..	100	....	100	15	...	15
Piute	10	..	10	..	3,600	....	3,600	120	...	120
Salt Lake	68	2	70	2	1,910	67	1,977	68	7	75
San Juan	10	1	11	1	774	200	974	90	5	95
Millard	1	..	1	1	....	116	116	....	1	1
Sevier	103	..	103	..	5,125	....	5,125	451	...	451
Tooele	102	..	102	..	2,102	....	2,102	290	...	290
Utah	195	..	195	5	9,316	....	9,316	1,238	...	1,238
Weber	50	..	50	1	1,607	....	1,607	169	...	169
Grand	....	..	....	19	....	....	....	....	...	....
Uinta	....	..	....	3	....	....	....	....	...	....
Washington	....	..	....	3	....	....	....	....	...	....
San Pete	156	..	156	..	4,070	....	4,070	209	...	209
Total	1,138	27	1,165	60	42,794	4,827	47,621	4,100	300	4.400

LOOKING DOWNSTREAM, BEAR RIVER IN UTAH.

A Mile south of the Wyoming boundary and before it enters Wyoming. From this point it is possible to divert the river into the Weber River watershed, that is into Echo Creek. On the route to Weber River are two large reservoir sites. Over 150,000 acre-feet are wasted here annually.

YEARLY DISCHARGE OF STREAMS IN STATE IN ACRE-FEET.

River.	Average Acre Ft. Run-off in	Years In the Average.	Measured at—
Bear	1,559,034	10	Collinston.
Logan	249,344	9	Logan.
Blacksmith Fork	155,156	8	Near Hyrum.
Box Elder	12,600	1	(1910) Brigham City.
Weber, Devil's Slide	456,633	6	Devil's Slide.
Weber, Plain City	888,900	5	Plain City.
Ogden (Ogden)	206,169	2	Mouth of Ogden Canyon.
Big Cottonwood	62,080	9	Near Salt Lake City.
Mill Creek	13,000	12	Near Salt Lake City.
Parley's Creek	20,070	11	Near Salt Lake City.
City Creek	13,260	10	Near Salt Lake City.
Emigration	2,600	6	Near Salt Lake City.
Summit Creek	12,500	1	(1910).
Spanish Fork (S. F.)	132,750	7	Spanish Fork.
Spanish Fork (Lake S.)	74,080	5	Lake Shore.
Hobble Creek	54,000	4	Hobble Creek.
Provo (mouth of Canyon)	319,830	7	Mouth of Provo Canyon.
American Fork	38,480	2	American Fork.
Provo (R. R. Bridge)	166,500	1	(1904). Railroad Bridge.
Sevier (near Gunnison)	232,320	8	Sevier (near Gunnison).
San Pitch	33,450	4	
Green River	6,400,710	7	Green River.
Duchesne	982,000	4	Myton.
Strawberry	55,558	1	Theodore.
Indian Creek	20,090	3	Just above mouth of creek.
Lake Fork	373,500	4	Near Whiterocks.
Uinta (Whiterocks)	219,870	5	Near Whiterocks.
Uinta (Ft. Duchesne)	216,800	6	Near Ft. Duchesne.
White Rocks	120,870	6	Whiterocks.
Ashley Creek	88,739	2	Vernal.
Price (Helper)	119,940	6	Helper.
San Rafael	317,200	2	Near Green River
Cottonwood	136,000	2	Orangeville
Ferron	44,500	2	Ferron.
Fremont	118,150	2	Thurber.
Muddy Creek	60,280	1	Emery.
Escalante	29,023	2	Escalante.
Virgin	198,000	2	Virgin.
Santa Clara	26,650	2	Central.
Huntington (Huntington)	151,000	1	Huntington.
Beaver Creek	29,450	2	Minersville.

The Uinta county streams are approximations. The data gave the flow for only seven to ten months, and from these approximations were made.

GRAND RIVER NEAR MOAB, UTAH.

Grand River rises in the western slopes of the Rocky Mountains, and when it passes Moab, Utah, is is a river of considerable magnitude. The lowest gauging station maintained upon it is at Palisade, Colorado, above Grand Junction, where the Gunnison joins it. Below Grand Junction it is swelled by the additional water from the Dolores River. It is probable that these two streams added to the flow of Grand River at Palisade bring it up to about the same volume as the flow of Green River at Green River City, Utah. These two streams are each nearly as large as Snake River's total discharge.

Combining the records of flow of Grand River at Palisade with the records for the Gunnison and Dolores Rivers, we find that the river is of the size described in the following paragraphs, by the time it reaches Moab. From the 1st of November to the last of February, Grand River at this point would seldom, if ever, carry less than 1000 second-feet. During March the river commences to rise, and from April to July, inclusive, the river is a tumultuous flood, reaching forty or fifty thousand cubic feet per second in volume. A low water season comes in August, September and October, but it is probable that its volume has never been less than 800 or 1000 second-feet even at this time.

The easiest way to get a clear understanding of the quantity of water in Grand River during the low water period, from August to October, is to compare it with better known streams in the central and western parts of Utah. Take the year 1908, which is the latest year for which the records have been published by the Government, as the basis of comparison:

During August, September, and October, 1908, the least quantity of water in Grand River at Palisade, Colorado, was 1,550 cubic feet per second, and this extremely low

stage was only five days long. Let us compare this least flow of Grand River with the largest flow of other streams in Utah.

The highest water in the Sevier in 1908, at any time in the year, did not reach one-half the quantity of the lowest stage of Grand River in the fall.

Grand River at Palisade, Colorado, carried twice the volume of water in 1908 that Bear River with all its tributaries carried into Great Salt Lake; and at Moab it probably carried over three times the volume of the Bear.

Logan River's greatest flood in 1908 was about half the least flow of the Grand in the fall.

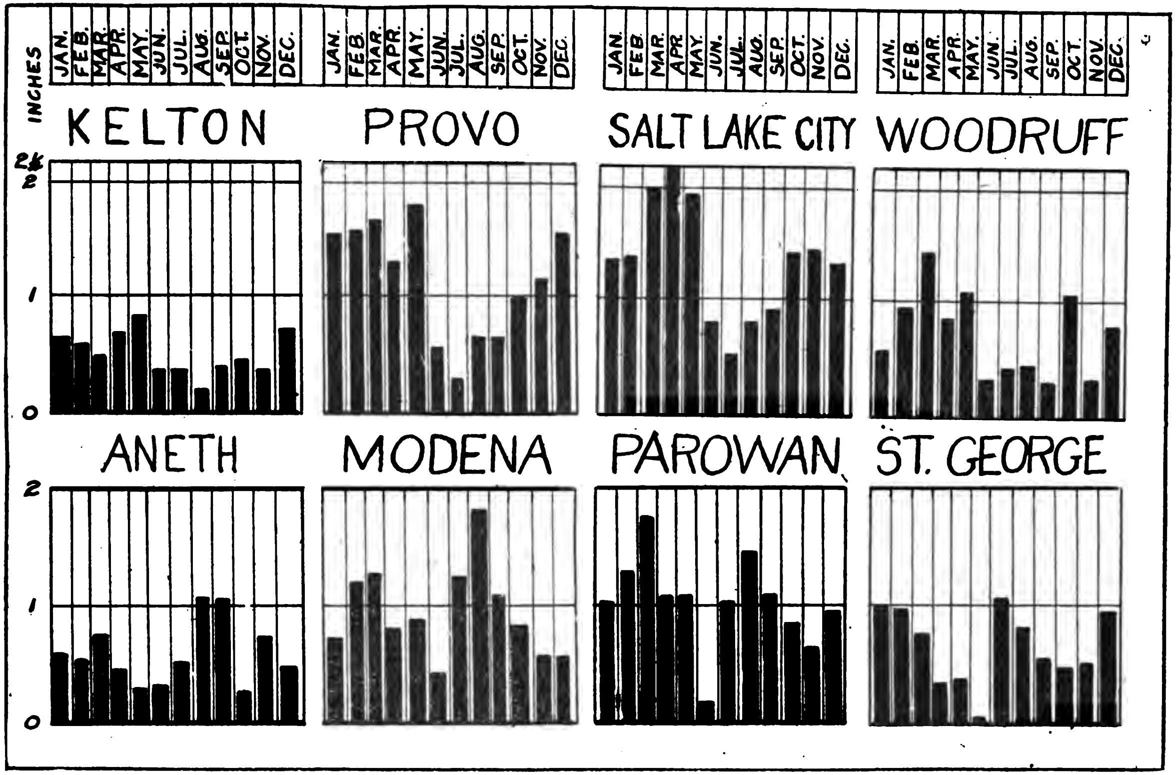
Weber River for only forty days during the spring floods of 1908 exceeded the least flow of the Grand in the fall.

Combine Bear River with its tributaries, Weber, Provo, Sevier, Spanish Fork, Beaver, Virgin, and Fremont Rivers, and their total volume in the year 1908 would not be so great as that of Grand River.

During the winter months, the flow of Grand River would be considered large even for spring floods on most of our streams.

Between Palisade and Moab the river falls about 600 feet, which would develop a minimum of 50,000 H. P., if it were possible to use all the fall. This is without any use of storage reservoirs which it is possible to build on the Grand.

THE CLIMATE



Diagrams, showing northern and southern types of rainfall in Utah. Note the spring and winter maxima at the northern stations, and the spring and late summer maxima at the southern stations.

The Climate of Utah as a Resource

(By Alfred H. Thiessen, U. S. Weather Bureau.)

A great waterpower is a natural resource of great value, perennially enriching those who control it, and benefiting in one way or another the entire community. A favorable climate is a natural resource of somewhat the same nature. It is a gift from the Creator to all, the rich and the poor, the strong and the weak.

Through its beneficent offices the land is watered and warmed and made productive of useful and beautiful plants and flowers. It conduces to the comfort of those who labor as well as to the opulent. Indeed, to the very elements of climate may be attributed the high or low energy and mentality of a people. The best climate urges them to a high efficiency in the field or shop, or to great attainments in science or philosophy.

What then are those fundamental climatic requirements which in their final effect constitute a natural resource? In general there should be moderate temperatures, a sufficiency of water and sunshine to grow the necessary food products in good quantities. If it is too warm nature is over-bountiful and man becomes indolent; if too cold all man's energy and time is spent in acquiring food and raiment, and as a result there is no development of the mentality.

To live in Utah is to appreciate that in her climate the people have a great natural resource. That is realization. To those who do not live in Utah I invite their attention to the following, which, let me hope, will be demonstration.

CLIMATE OF UTAH IN GENERAL.

The climates of the world are usually classified as continental, marine and mountain. Due to its geographic position inland and to its mountainous and plateau character, Utah has all the essential features of a continental and moun-

tain climate. These features in general are: wide daily, monthly, yearly ranges in temperature, pronounced seasonal changes, dryness and rareness of the air, large amount of and strong sunshine.

The physical factors that determine climate of a place are (1) latitude, (2) elevation, (3) position in relation to large bodies of water, and (4) position relative to the prevailing winds as controlled by the movement of cyclones and anti-cyclones.

Utah lies between the 37th and 42nd parallels of latitude. Its elevation varies from 2800 feet in the lower portions of Washington county to nearly 14000 feet, the height of some mountain peaks in the Uintas far to the northeast, but the greater portion of the State lies between 4000 and 6000 feet. Latitude is principally important as controlling temperature; for, as a rule, temperature decreases from the equator to the poles. Other factors being equal elevation and remoteness from the ocean cause a dry atmosphere; while elevation alone accounts for the rareness of our atmosphere and the low temperatures both in summer and winter.

The mean annual temperatures in Utah range from 40° in the extreme north to nearly 60° in the extreme south part of the State, or about the same as the temperatures in southern New York and northern Pennsylvania.

In the study of annual mean temperatures consult not only Table 1, but also Chart I. Note how the temperature lines, or isotherms run nearly north and south, following the main mountain range. It is interesting to see how in Utah topography is of more effect in causing differences in temperature than latitude. In the case of a flat state, the isotherms would run nearly east and west, following the parallels of latitude.

In Utah the January temperatures are about equal to those of the Middle states; while the July temperatures compare with the middle Atlantic states, as Virginia and North Carolina.

Due to its elevation the air is rare, but not so light as to cause mountain sickness. The rare air permits of rapid radiation causing delightfully cool nights in summer, which would perhaps be more appreciated if they followed depressing, muggy days. On account of the high Coast Range, causing most of the moisture which the winds gather from the Pacific Ocean to be precipitated on the western slope of these mountains, the air is dry here and this dry air with moderate wind velocities produces rapid evaporation from the skin, making the high summer temperatures enjoyable rather than debilitating.

The cold wave as it is defined by the U. S. Weather Bureau seldom reaches Utah. The cold wave is peculiar to all sections that feel the tremendously big changes in temperature due to the passing of cyclonic storms of a strong winter type.

On the other hand Utah is not subject to the hot wave or long heated term, for the reason that no matter how warm the day may be, as soon as the sun sets, rapid radiation takes place under the influence of clear skies and rare air.

PRECIPITATION.

In general no place can have abundant precipitation and be situated remote from the ocean, and this factor of climate is accentuated if a high mountain range lies between the source of moisture and the place considered. This is so in Utah; the rain-bearing winds from the Pacific Ocean are deprived of most of their moisture on the windward slope of the Sierras, so that the yearly amounts in Utah do not compare with those on the Pacific slope or in the eastern states.

For personal comfort a small amount of rainfall is better than large; it is much more enjoyable to have it fair underfoot as well as overhead. This state of affairs is the rule in this State; for, on account of the limited rainfall, agriculture is carried on by irrigation and dry-farming methods, both brought to a high state of perfection. Here the farmer

works through the growing season with clear skies, and hears running merrily along his irrigating ditch water which fell as snow in the high mountain canyons, and conserved there for his use during the growing season.

As shown by the table and chart of annual precipitation the local yearly amounts vary from 6 to 20 inches. But the distribution of this moisture is such as to make it most efficient. Note on the chart showing types of rainfall that there are two distinct types, the northern and southern, but the southern type is evident only in the southern third of the State. It is seen that most of the moisture falls during winter and spring. In the winter it is in the form of snow. As precipitation increases with elevation, much larger amounts than are shown in the table occur at the higher places, and comprise the storage moisture for irrigation, and in the spring rains are needed to start vegetation.

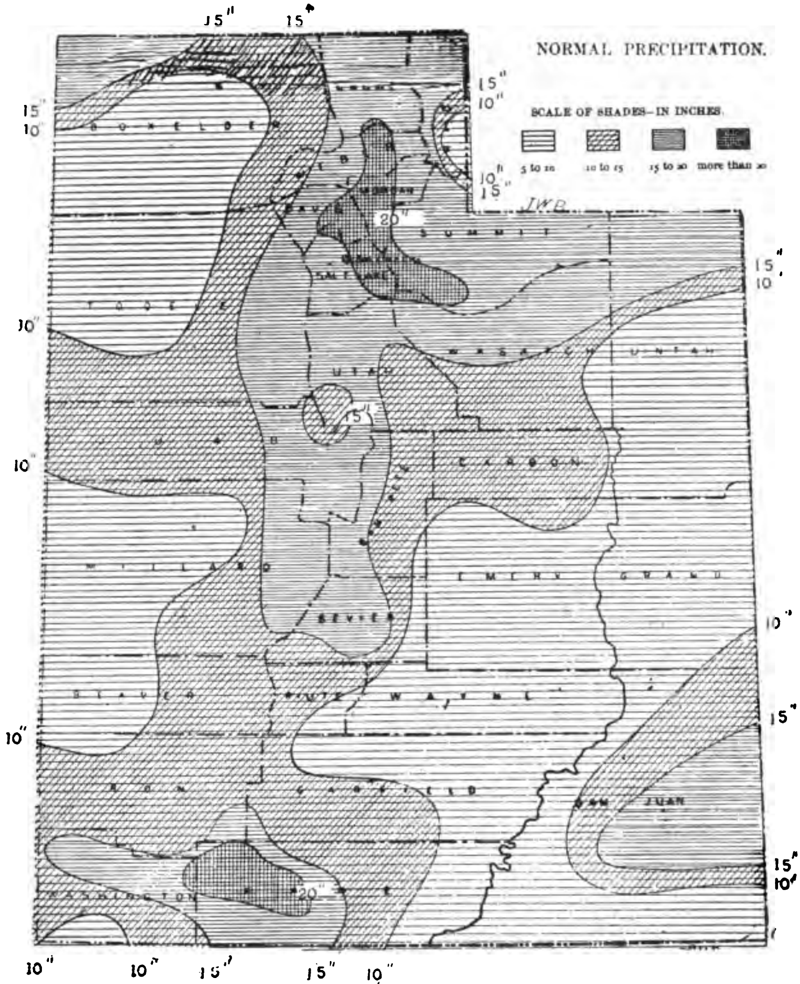
CLIMATE OF SALT LAKE CITY, UTAH.

As more complete weather records were kept at Salt Lake City, Utah than in other cities of the State, and as the records at that place are applicable to most other places in the State at the same altitude, a special table was prepared and produced showing many important elements not given for the entire State.

The temperature of a place to be a resource must neither be too high or too low. The most disagreeable characteristic of temperature, disagreeable to man and destructive to tender plants in the spring and fall, is a large daily change or variability in temperature. To illustrate: suppose that the average temperature at a place on a certain day was 50 and the average for the next day was 45, then the change would be 5. At Salt Lake City the average daily change is only 4, and varies from 4 in April to 5 in August. In this respect Salt Lake City compares very favorably with all inland cities in this latitude.

The humidity table does not show extreme dryness or an excessive amount of water vapor. The winds are mod-

erate and the sunshine sufficient. There are only 89 rainy days on the average: a rainy day is one on which 0.01 inch or more of moisture falls. There are more cloudy days in winter than in summer which accounts in part for the comparatively mild winter temperatures with small daily ranges.


NORMAL PRECIPITATION.
SCALE OF SHADES—IN INCHES.
5 to 10
10 to 15
15 to 20
more than 20
15"
10"
20"
SUMMIT
SALT LAKE
UTAH
UINTAH
CARBON
EMERY
GRAND
SEVIER
WAYNE
GARFIELD
SAN JUAN
WASHINGTON
MILLARD
BEAVER
IRON
JUAB
TOOELE
WASATCH
MORGAN

NORMAL ANNUAL TEMPERATURES.

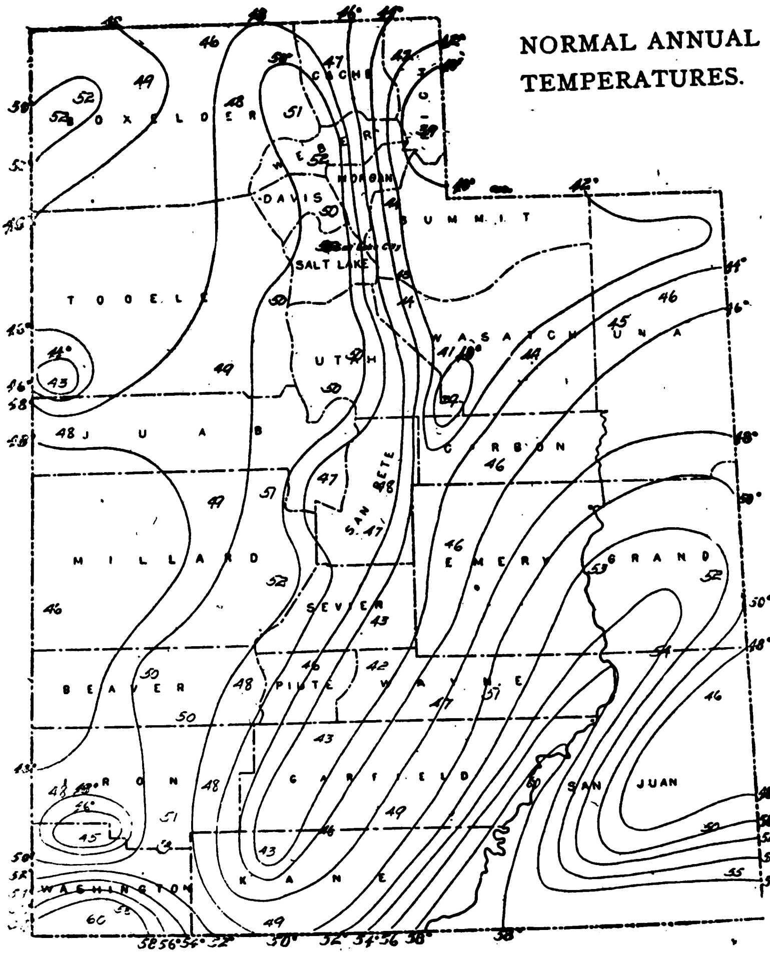


TABLE I.—MEAN TEMPERATURES FOR UTAH.

Stations	Counties	Length of Record	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Castle Dale	Emery	12	21.3	26.4	38.4	46.2	53.6	63.5	69.5	67.8	58.8	47.8	37.6	23.4	46.2
Cisco	Grand	12	24.4	29.8	42.0	53.1	62.4	71.9	79.8	77.3	67.0	52.2	39.3	25.6	52.1
Corinne	Boxelder	41	24.8	30.0	40.3	50.6	60.2	70.5	78.9	74.4	65.2	50.3	37.4	28.4	50.9
Deseret	Millard	16	27.6	31.3	40.8	48.1	55.9	65.1	72.4	71.2	60.5	49.3	37.4	25.9	48.8
Emery	Emery	10	25.4	30.2	38.5	45.1	51.5	59.6	65.9	65.9	56.1	47.2	37.9	27.0	45.9
Farmington	Davis	10	29.4	33.0	40.9	48.6	55.6	64.3	72.5	70.4	60.0	50.2	40.6	30.7	49.7
Fillmore	Millard	19	30.9	34.0	41.6	50.1	57.4	67.7	75.4	74.4	65.2	52.8	42.1	30.3	51.8
Ft. Duchesne	Uinta	23	12.6	18.5	36.1	48.2	56.0	64.9	71.1	69.5	60.7	46.6	33.7	17.6	44.6
Frisco	Beaver	15	31.9	33.6	38.9	47.0	55.2	68.3	74.2	71.8	62.7	49.7	39.9	31.4	50.4
Gov. Creek	Tooele	10	28.1	31.0	38.7	46.9	53.0	63.1	73.2	71.9	61.4	49.5	39.0	28.3	48.7
Green River	Emery	10	24.9	34.6	47.3	54.3	63.4	73.9	80.0	76.9	65.7	53.2	39.9	23.8	53.2
Heber	Wasatch	18	21.5	23.9	34.7	44.4	51.9	59.2	66.1	64.8	55.4	45.3	35.3	22.2	43.7
Henefer	Summit	11	23.0	26.3	35.9	43.9	50.9	58.3	65.0	64.2	55.0	45.2	35.4	23.8	43.9
Hite	Garfield	11	36.3	42.7	51.2	59.3	67.8	77.8	84.7	82.6	72.7	60.2	47.7	35.6	59.9
Kelton	Boxelder	31	22.9	28.6	40.0	49.0	58.3	69.3	77.0	74.2	61.0	47.7	34.4	27.1	49.1
Levan	Juab	21	24.3	28.5	37.1	46.6	54.3	62.8	71.6	69.9	60.2	47.5	37.0	25.4	47.1
Loa	Wayne	18	24.6	24.1	32.2	40.5	48.7	58.6	65.9	62.9	53.0	41.3	31.1	20.9	42.0
Logan	Cache	20	24.2	26.2	35.7	47.7	54.5	63.2	71.7	70.7	61.5	49.8	37.9	25.6	47.4
Manti	Sanpete	16	25.5	28.0	37.8	46.8	55.8	64.7	70.0	68.3	59.5	47.7	37.3	25.1	47.2
Marysvale	Piute	11	28.5	28.9	38.2	45.1	50.7	59.5	65.8	64.9	57.9	47.4	37.2	25.9	45.8
Meadowville	Rich	10	23.1	22.0	29.7	41.1	48.6	56.0	64.4	63.6	54.2	43.5	33.8	25.8	42.2
Moab	Grand	21	29.8	36.3	46.8	55.4	63.9	72.1	77.6	75.2	66.0	53.5	41.2	30.5	54.0
Modena	Iron	10	27.5	31.6	39.2	46.9	54.5	63.2	69.7	68.6	60.2	50.1	39.0	31.7	48.5
Ogden	Weber	40	29.0	33.2	41.5	52.6	62.7	71.4	73.9	76.7	65.1	51.7	39.4	31.5	52.4
Parowan	Iron	20	29.0	31.5	39.1	47.2	55.0	64.1	71.0	69.3	59.3	49.1	39.0	28.8	48.5
Pinto	Washington	13	27.4	30.6	35.8	44.0	49.5	59.3	66.6	64.9	56.2	44.9	36.4	27.1	45.2
Promontory	Boxelder	32	22.2	28.0	37.7	47.7	57.8	68.2	74.7	75.0	62.8	48.9	34.3	26.0	48.6
Provo	Utah	17	27.5	31.5	40.7	49.9	57.5	64.8	73.3	71.1	60.9	49.3	39.8	28.9	49.6
Richfield	Sevier	17	27.6	32.3	40.2	47.4	56.3	63.6	70.5	67.7	59.0	48.1	37.6	28.1	48.2
St. George	Washington	24	37.6	42.0	49.4	57.4	66.8	76.5	82.3	80.8	71.2	59.2	47.4	37.9	59.9
Salt Lake	Salt Lake	39	28.8	32.9	41.4	50.1	58.3	68.3	76.2	75.5	65.1	52.2	40.4	32.1	51.8
Scipio	Millard	16	27.4	31.6	38.6	46.8	53.3	63.3	69.9	68.6	60.0	47.7	37.2	27.3	47.6
Thistle	Utah	17	25.4	29.9	37.5	48.0	54.1	63.0	70.5	69.4	58.8	48.7	37.2	26.6	47.4
Tooele	Tooele	15	29.8	32.8	40.0	49.0	55.4	65.6	73.4	72.6	63.4	50.5	39.9	29.3	50.1
Tropic	Garfield	14	27.2	30.1	37.9	45.0	52.1	61.5	67.5	64.6	57.7	47.7	37.5	28.8	46.5
Vernal	Uinta	14	18.2	22.4	36.2	48.6	56.5	65.9	71.8	69.8	60.2	47.0	34.9	17.7	45.8
Woodruff	Rich	12	17.6	18.0	29.2	39.4	47.7	55.6	60.8	60.4	51.6	40.6	30.6	19.8	39.3

TABLE II.—MEAN MAXIMUM TEMPERATURES.

Stations	January	February	March	April	May	June	July	August	September	October	November	December
Fillmore	46	47	56	65	77	90	97	94	85	71	59	45
Levan	38	39	49	61	70	83	89	86	76	63	51	37
Loa	39	40	47	58	68	80	88	84	75	61	50	42
Logan	35	32	47	57	67	79	86	84	74	61	48	35
Moab	44	49	62	72	81	92	96	94	85	72	59	43
Modena	43	39	49	61	71	83	88	87	77	67	53	43
Provo	42	43	55	64	75	84	92	91	81	68	56	41
St. George........	56	57	67	76	86	97	101	98	91	79	65	55
Salt Lake City....	36	41	50	60	69	79	88	87	77	63	49	40
Snowville	36	36	44	59	65	81	88	85	76	64	50	37
Vernal	33	36	50	63	74	85	89	87	78	65	51	36

TABLE III.—MEAN MINIMUM TEMPERATURES.

Stations	January	February	March	April	May	June	July	August	September	October	November	December
Fillmore	19	16	27	33	40	49	55	55	44	35	27	17
Levan	17	17	25	31	39	47	53	53	42	34	26	15
Loa	3	4	13	20	28	37	45	40	30	21	14	1
Logan	21	20	28	36	44	52	57	57	47	39	30	21
Moab	17	21	31	37	46	53	58	57	47	39	29	17
Modena	17	14	23	30	38	48	53	54	43	34	25	16
Provo	22	19	29	34	40	47	51	52	41	34	30	20
St. George........	19	22	28	36	44	52	58	54	46	38	27	17
Salt Lake City....	21	25	32	40	47	55	63	62	52	42	32	21
Snowville	16	16	25	31	36	42	49	47	40	32	26	15
Vernal	11	13	21	33	42	50	55	53	43	34	24	11

TABLE IV.—AVERAGE PRECIPITATION IN UTAH.

Stations	Counties	Length of Record	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Alpine	Utah	12	1.48	2.02	2.11	1.95	2.62	.71	.65	1.37	1.21	1.48	1.54	1.16	18.25
Castle Dale	Emery	12	.66	.78	.42	.66	.44	.55	.54	1.10	.90	.60	.97	.60	8.22
Cisco	Grand	13	.57	.82	.51	.30	.66	.11	.22	.34	.66	.65	.35	.50	5.69
Corinne	Boxelder	41	1.37	1.24	1.40	1.09	1.46	.57	.46	.58	.69	1.02	1.04	1.55	12.47
Deseret	Millard	16	.48	.86	.97	.89	1.16	.37	.24	.57	.84	.56	.47	.55	7.96
Emery	Emery	10	.42	.80	.27	.31	.46	.38	.42	1.57	1.12	.62	.44	.53	7.34
Farmington	Davis	11	2.38	2.58	2.39	1.87	2.99	.86	.50	.87	1.11	1.39	1.62	2.03	20.59
Fillmore	Millard	19	1.08	1.44	1.99	1.67	1.75	.52	.70	.95	1.27	1.14	1.00	1.10	14.61
Ft. Duchesne	Uinta	23	.49	.48	.64	.54	.74	.27	.51	.79	1.11	.57	.38	.57	7.09
Frisco	Beaver	15	.49	.78	.78	.61	.87	.32	.81	1.21	.76	.75	.50	.40	8.28
Gov. Creek	Tooele	10	1.25	1.43	2.21	1.31	1.49	.62	.55	1.24	.95	.80	1.15	.88	13.88
Green River	Emery	11	.25	.54	.36	.60	.55	.08	.23	.79	.91	.23	.57	.23	5.34
Heber	Wasatch	18	2.36	2.11	2.20	1.28	1.62	.53	.82	1.04	1.04	1.20	1.36	1.79	17.35
Henefer	Summit	11	2.51	2.42	2.43	1.50	1.94	.69	.80	1.20	1.14	1.14	1.70	1.67	19.14
Hite	Garfield	10	.59	.68	.65	.38	.58	.20	.40	.72	.77	.36	.94	.64	6.91
Kelton	Boxelder	32	.67	.63	.51	.70	.84	.37	.36	.20	.39	.47	.37	.74	6.25
Levan	Juab	22	1.46	1.59	2.09	1.69	1.77	.55	.61	.95	1.29	1.17	.96	1.71	15.84
Loa	Wayne	18	.48	.58	.62	.56	.32	.16	.92	1.24	.56	.40	.37	.35	6.56
Logan	Cache	20	1.55	1.41	1.96	1.59	2.37	.79	.49	.77	1.11	1.30	1.23	1.11	15.68
Manti	Sanpete	14	1.27	1.42	1.55	1.06	1.18	.37	.59	.69	1.26	.88	.96	.93	12.16
Marysvale	Piute	11	.66	.95	1.84	.78	1.05	.30	.98	1.67	1.65	.92	.92	.82	12.04
Meadowville	Rich	11	2.08	2.18	1.84	1.88	1.86	.86	.49	1.02	1.12	1.32	1.30	1.07	17.02
Millville	Cache	16	1.77	1.38	2.06	1.70	2.30	.82	.44	.92	1.19	1.55	1.65	1.17	16.95
Minersville	Beaver	10	.99	.92	1.60	1.02	1.35	.33	.71	1.33	.70	.78	.89	.92	11.54
Moab	Grand	21	.67	.65	.92	.51	.76	.25	.59	.72	1.09	.66	.70	.84	8.36
Modena	Iron	10	.73	1.20	1.30	.79	.87	.40	1.26	1.83	1.12	.82	.60	.58	11.50
Ogden	Weber	40	1.62	1.61	1.83	1.38	1.82	.68	.26	.56	.76	1.31	1.14	1.70	14.67
Parowan	Iron	20	1.04	1.37	1.77	1.12	1.13	.19	1.03	1.48	1.10	.86	.69	.93	12.71
Pinto	Washington	14	1.37	1.48	2.07	1.00	.95	.22	1.12	2.04	1.46	1.35	1.32	.83	15.21
Promontory	Boxelder	36	1.02	.91	.73	.67	.86	.49	.21	.39	.59	.56	.58	.91	7.92
Provo	Utah	17	1.52	1.54	1.67	1.30	1.80	.60	.28	.68	.68	.98	1.14	1.53	13.72
Richfield	Sevier	17	.66	.78	.94	.56	.49	.33	.58	.74	.60	.79	.42	.71	7.60
St. George	Washington	29	1.00	.96	.75	.36	.38	.07	1.07	.79	.56	.49	.51	.93	7.87
Salt Lake	Salt Lake	39	1.35	1.38	2.00	2.26	1.95	.77	.54	.78	.85	1.40	1.42	1.33	16.03
Scipio	Millard	16	1.36	1.78	2.12	1.29	1.53	.37	.69	1.06	1.13	1.26	1.24	1.16	14.99
Thistle	Utah	17	1.80	1.67	1.68	1.07	1.21	.51	.59	1.01	1.29	.58	1.00	1.49	13.90
Tooele	Tooele	15	1.23	1.32	2.09	1.67	2.41	.67	.61	1.03	.97	1.31	1.53	1.05	15.89
Tropic	Garfield	13	.91	.83	.75	.88	.71	.41	.91	1.77	1.32	.74	1.03	.66	10.92
Vernal	Uinta	14	.64	.60	.81	.71	.97	.36	.78	.74	1.27	.84	.74	.56	9.02
Woodruff	Rich	12	.60	.92	1.42	.81	1.09	.31	.44	.46	.28	1.05	.30	.78	8.46

TABLE V.—FROST DATA.

Stations	Length of Record—Years	Average Date of First Killing Frost in Autumn		Average Date of Last Killing Frost in Spring		Earliest Date of Killing Frost in Autumn		Latest Date of Killing Frost in	
Aneth	8	Sept.	25	April	20	Sept.	12		
Castle Dale	10	Sept.	17	June	2	August	21		
Corinne	12	Oct.	4	May	16	Sept.	16	June	7
Emery	8	Sept.	24	June	5	Sept.	12	June	22
Farmington	9	Sept.	24	May	15	Sept.	8	June	16
Ft. Duchesne	21	Sept.	22	May	15	August	31	June	28
Gov. Creek	9	Sept.	30	May	24	Sept.	12	June	23
Grayson	7	Sept.	26	May	27	Sept.	6	June	26
Green River	10	Sept.	22	April	27	Sept.	11	May	31
Heber	16	Sept.	2	June	14	August	11	July	20
Hite	7	Oct.	28	April	11	Oct.	19	May	24
Kanab	3	Oct.	8	May	22	Sept.	29	June	15
Kelton	32	Oct.	4	May	5	Sept.	9	May	17
Levan	9	Oct.	4	May	17	Sept.	12	June	25
Logan	19	Oct.	8	May	10	Sept.	14	June	17
Manti	16	Sept.	22	May	23	August	31	June	23
Marysvale	10	Sept.	17	May	26	August	31	June	23
Moab	17	Oct.	3	April	21	Sept.	12	June	17
Modena	9	Sept.	21	May	18	Sept.	12	May	30
Ogden	14	Sept.	25	April	25	Sept.	25	May	20
Parowan	19	Oct.	17	May	19	Sept.	12	June	16
Provo	14	Oct.	3	May	12	Sept.	9	June	29
Richfield	14	Sept.	15	May	28	Sept.	1	June	30
St. George	16	Oct.	11	April	22	Sept.	21	May	20
Salt Lake City	35	Oct.	18	April	19	Sept.	3	May	31
Vernal, near	13	Oct.	1	May	12	Sept.	12	June	16

METEOROLOGICAL DATA BY MONTH FOR SALT LAKE CITY, UTAH.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Monthly Mean Temperature	28.8	32.9	41.4	50.1	58.3	68.3	76.2	75.5	65.1	52.2	40.4	32.1	51.8
Highest Monthly Mean	38.2	42.9	49.6	55.2	63.4	73.8	80.2	78.4	70.6	58.2	46.6	38.4	54.3
Lowest Monthly Mean	20.6	20.0	33.6	45.6	51.4	60.2	71.9	69.8	59.4	46.3	29.6	24.0	48.5
Highest Temperature	60	68	77	85	93	101	102	101	93	88	74	61	102
Year	1911	1879	1879	1910	1887	1900	1889	1875	1875	1910	1898	1874	1889
Date	31	27	30	26	31	28	30	6	6	10	6	1	July 30
Lowest Temperature	—20	—13	0	18	25	33	43	44	29	22	—2	—10	—20
Year	1883	1884	1890	1896	1899	1898	1902	1880	1895	1878	1896	1879	1883
Date	20	13	1	1	2	3	8	31	22	26	29	25	Jan. 20
Average Highest Temperature	36.5	41.1	50.6	60.1	68.4	79.1	88.2	86.7	76.5	62.9	49.7	39.4	59.9
Average Lowest Temperature	21.5	25.6	32.5	39.8	46.6	54.9	63.0	62.4	52.5	42.0	31.3	25.0	40.3
Average Daily Range	15.0	15.5	18.1	20.3	21.8	24.2	25.2	24.3	24.0	20.9	18.4	14.4	19.6
Average Daily Change	4.1	4.1	4.3	5.2	4.8	4.5	3.3	2.9	4.1	3.8	4.0	3.8	4.1
Number Times Max. Temperature 90° or above	0	0	0	0	5	103	472	371	25	0	0	0	976
Number Times Min. Temperature 32° or below	981	763	524	157	0	0	0	0	3	89	526	933	3976
Number Times Min. Temperature 20° or below	495	273	55	2	0	0	0	0	0	0	90	334	1249
Number Times Min. Temperature Zero or below	20	13	1	0	0	0	0	0	0	0	3	4	41
Monthly Total Precipitation	1.35	1.38	2.00	2.26	1.95	.77	.54	.78	.85	1.40	1.42	1.33	16.03
Percentage of Annual	8.4	8.6	12.4	14.1	12.2	4.8	3.4	4.9	5.3	8.7	8.9	8.3	...
Greatest Monthly Amount	3.07	3.81	4.66	4.43	5.76	2.67	2.42	2.28	3.15	3.85	5.81	4.87	...
Least Monthly Amount	0.63	0.38	0.33	0.66	0.06	0.01	T	0.02	T	0.24	T	0.11	...
Greatest in 24 Hours	0.64	1.32	1.12	1.38	2.72	2.00	.77	1.04	1.84	1.14	1.56	1.38	...
Average Snowfall	10.9	10.5	9.5	2.7	0.5	0	0	0	0	.09	6.0	9.8	50.8
Greatest Monthly	30.8	29.0	20.7	8.0	6.0	T	0	0	0.2	6.3	27.8	23.7	...
Least Monthly	1.8	0	T	0	0	0	0	0	0	0	0	0	0
Average Relative Humidity, 6 A. M.	76	72	66	58	58	49	46	48	50	60	67	77	62
Average Relative Humidity, 6 P. M.	72	64	51	39	36	28	25	28	32	47	60	73	47
Prevailing Wind	SE	SE	SE	NW	NW	SE	SE	SE	SE	SE	SE	SE	SE
Average Hourly Velocity	4.8	5.3	6.7	7.2	6.9	6.6	6.3	6.1	6.4	5.6	5.2	4.6	6.0
Percentage of Sunshine	44	47	54	57	64	75	84	73	76	69	58	43	62
Average Number Rainy Days	10	10	10	9	8	5	4	5	4	7	7	10	89
Average Number Clear Days	9	7	10	10	11	16	18	16	18	16	13	9	153
Average Number Partly Cloudy Days	9	9	10	11	12	10	10	11	8	8	8	9	115
Average Number Cloudy Days	13	12	11	9	8	4	3	4	4	7	9	13	97

MINERALS

COAL.

The estimated coal area of Utah is 13,130 square miles, with an additional 2,000 square miles that may contain workable coal seams, divided into three coal regions: the Uinta region, embracing Carbon, Emery, Grand and Uinta counties on the East; the Southwestern Utah region, embracing Iron, Kane, Washington, Beaver and San Juan counties on the South; and the Weber region, embracing Summit and Morgan counties on the North.

The estimated tonnage in these three regions, easily accessible and accessible with difficulty, is 196,458,000,000 tons; the total approximate amount of coal extracted from the Utah coal fields is 34,000,000 tons, and probably 12,000,000 tons more have been lost through crude and indifferent systems of mining during the early days of coal mining in this State. Out of the 13,130 square miles containing workable coal, not more than 20 square miles have been filed on, not including coal lands given by the Government to railroad companies on the early land grants.

The coal produced for 1912 was 3,088,356 tons, an increase of 586,885 tons over 1911. The production of the hydro-carbon mines was 35,627, a decrease of 1,423 tons from 1911. The production of coke was 347,356 tons, an increase of 134,988 tons.

The amount of explosives used were: Black powder, 356,500 pounds; giant powder, 395,218 pounds (which includes Monobel, Bental No. 2 and other permissible powders), a total of 751,798 pounds, or one pound of powder being used for every 4.1 tons of coal mined. This also shows a decrease in the amount of black powder used, and a corresponding increase in the use of the permissible powders, as tested by the United States Bureau of Powder Tests.

Four thousand forty-one men were employed in and around the coal and hydro-carbon mines and coke plants during the year, an increase af two hundred and forty-one men over

last year. The average number of days worked at the various mines was 240. Average amount of coal produced per man, including miners, day men and outside men, but not including coke workers, 840 tons. Average amount of hydro-carbon produced per man, 286 tons.

Carbon county takes the lead of counties in coal production, and up to the present time has furnished more than 95 per cent of the entire coal output of the State. The quality of the coal in Carbon and Emery counties is without question the best grade of bituminous coal in the West, and its storing quality will readily recommend it to the people of these Western States, whose chances for winter fuel lie in the hauling and storing of coal during summer months.

In Carbon county are the Sunnyside coal mines, with an output of 2,600 tons per day, which can readily be increased to 3,500 tons per day. Here are located 640 coke ovens, producing a high grade of coke, all of which product is used in the Utah, Nevada, California and Montana smelters. Seventy-eight per cent of the production of these mines is now being used for coking purposes.

There are two seams of coal worked at the Sunnyside colliery, ranging from five to eleven feet thick, containing the best coking coal in the State. The Castle Gate mines, Nos. 1, 2 and 3, are in operation, producing 1,250 tons per day, which output will be increased to 2,000 tons per day by January 1, 1913. No. 3 mine is situated in Willow Creek Canyon, and is the latest addition to the Utah Fuel Company's group. A new steel tipple with the latest improved shaking screens has recently been put in operation, at a cost of $30,000, to handle the output of the three mines. Mine No. 3 being connected with the tipple by a motor haulage system one mile in length.

The Clear Creek mines, Nos. 1 and 2, produce 1,400 tons per day, the thickness of the seams being twelve feet. The product of these mines is in great demand for domestic purposes.

Winter Quarters mines, Nos. 1 and 4 (the former being about the oldest producing mine of the State, the latter the mine where the disaster of May 1, 1900, occurred), have been equipped with a new steel tipple and up-to-date loading devices. These mines are producing 1,800 tons per day, part of which product is used for commercial purposes, and part for railroad purposes.

The Utah mine, located between Winter Quarters and Clear Creek, has an output of 500 tons per day, which is used entirely for railroad purposes.

The above mentioned mines are all owned and operated by the Utah Fuel Company.

The mines at Kenilworth, known as the Aberdeen and Royal Blue mines, are sending their product of 1,600 tons per day to all parts of the Western States. The product is used for commercial purposes, and is recognized as a favorite fuel for steam engine and domestic uses. A number of improvements are being made this year at these mines, $40,000 having been appropriated for equipment, consisting of electric generators, chain mining machines, and a new ventilating fan. The Aberdeen seam is twenty feet thick and the Royal Blue is nine feet thick. This property is owned and operated by the Independent Coal and Coke Company.

At Spring Canyon, the Knight Investment Company of Provo is developing a very promising coal property containing three workable seams of excellent domestic and steam coal. The seams are 8 feet 3 inches, 4 feet 8 inches, and 12 feet in thickness. Grading for the four and one-half miles of track, connecting the D. & R. G. at Helper with the mine, is half completed; contracts for the power plant, tipple, and an aerial tramway to deliver the coal from the mine to the tipple have also been let, and coal from this property will be on the market by the first of January.

The Consolidated Fuel Company's property has developed wonderfully during the past two years, and two producing mines are opened in such a manner that there is practically no limit to the amount of coal that can be produced

from these mines when the demand requires it. These mines are working the same seam, No. 1 mine being on the south and No. 2 mine on the north side of the canyon. The product of these mines is known as "Hiawatha coal," Hiawatha also being the name of the town. The Hiawatha seam averages sixteen feet in thickness.

Black Hawk is a new property, adjoining the Consolidated Fuel Company, some three miles south, working the same seam under practically the same conditions. This mine has up-to-date equipment for handling a large output of coal and a town of thirty houses has been built.

The Castle Gate Coal Company is the name of another promising property at present being developed near the town of Castle Gate by the Utah Coal Company, the product being hauled by team and loaded on railroad cars at the mouth of Willow Creek.

In addition to these mines, there are six other properties in this county that supply the local demand during the winter months. The mines at present in operation in Carbon and Emery counties are all working practically the same seam, which has been conceded to be the most extensive body of coal in the West and best for steam, coke and domestic purposes, being uniformly clean, free from rock bands, bone and other foreign matter.

The Castle Valley Coal Company's property, producing what is known commercially as "King coal," is located in Emery county and will be one of the largest producers of the State. Considerable improvements at this mine have been and are being made, including a new hotel and thirty-five new houses. The town is known as "Mohrland."

The Castle Valley Coal Company, along with the Black Hawk Coal Company, was transferred last March from the original owners to the Utah Coal Company, a corporation organized under the laws of New Jersey and consisting principally of the president and directors of the United States Smelting & Refining Company of Boston, Mass. During the past two months, the Utah Coal Company has acquired a con-

trolling interest in the Consolidated Fuel Company, has organized the Castle Gate Coal Company, and is now operating four splendid coal properties. Under the direction of this company, surveys have been run to determine the best location for a coal road, to handle the product of these mines and make connections with the Salt Lake Route.

There are some forty coal openings in this county, where coal is mined during the winter months to supply coal for family trade, and but a very small per cent of the coal in this county has been filed on or acquired.

The organizing of independent coal companies during the past three years and the development of their properties has brought about a peculiar condition. Each company endeavors to place a superior grade of coal on the market, and to accomplish this end, re-screening devices (in addition to up-to-date screening methods) have been introduced, by which the dust or very fine coal is taken from what was formerly sold as slack, making a clean slack or pea coal for the market. Part of the fine dust is used as ballast for the railroads, and the remainder is thrown away on large dumps which fire by combustion, and thousands of tons are thus wasted annually.

The Conservation Commission would ask if this waste of our natural resources could not be eliminated and the waste product put to a commercial use. There is at least one way in which this waste product can be used to a commercial advantage, and that is by the erection of steam power plants for the development of electricity, the plants to be at or near some of our large coal mines where this slack is thrown away. This waste fuel material can be obtained at small cost, and with ample boiler capacity electric power could be generated cheaply.

In Uinta county there are eight small coal mines in operation. The vein is six feet thick, and by geologists is listed in the Colorado age. The present operations are six miles west of Vernal, and have a total yearly output of 2,000 tons. The area of the coal field in this district covers some

ten square miles, and not more than 400 acres have been secured. The coal is of a sub-bituminous grade.

Grand county has a large undeveloped coal area. The prospector has not as yet been enticed into this district, except at a few points near the D. & R. G. Railroad.

Four and one-half miles north of Thompson's Spring Station, a new mining town has sprung up this year named "Neslen." A mine is being developed and a coal washery is being installed to handle the product of two splendid seams of bituminous coal, averaging about six feet in thickness, with a larger seam untouched. This work is being done by the American Fuel Company, a company formed by a number of business men of Salt Lake City. The spur from the D. & R. G. railroad at Thompson's to the mine is practically completed and coal will be shipped over this road by October 1. Another land sale, or local mine, is being developed by Green River parties, six miles from Crescent Siding.

The Uintah region contains a total of 9,000 square miles of workable coal.

The Southwestern Utah region, containing 3,000 square miles of coal land, is practically untouched. These coals occur in the Colorado group, and the nearest railroad point is the San Pedro, Los Angeles & Salt Lake railroad at Lund, some thirty-five miles from the coal cropping in Coal Creek, just east of Cedar City, Iron county.

There are a number of openings on the vein in Iron county, which averages five feet six inches in thickness, from which winter coal for nearby settlements is secured, each claim or filing averaging sixty acres each.

There are the Jones & Bullock, the Cluff, Wood and Taylor, all in Coal Creek Canyon; Leyson, Lunt, Corry, Culver and Kanarraville mines on the Colob Plateau between Cedar City and Kanarraville.

There is an area of semi-anthracite about four miles from New Harmony in Washington county, that is owned by Los Angeles capitalists who are trying to organize a

Outcrop of Large Coal Vein.

company to build a railroad from the San Pedro, Los Angeles & Salt Lake railroad to their property at New Harmony. A fair grade of cannel coal has been found on the Virgin river, in this region, the vein running about seven feet in thickness. In fact, but little is known of the mineral resources of this region.

The Weber region embraces some forty square miles and belongs to the Colorado age. This coal is a sub-bituminous grade, well adapted for steam and domestic uses. There are two veins of coal, averaging nine and four feet. Four mines are being worked in this region, three in Summit county and one in Morgan county. The principal mines in Summit county are the Wasatch and Grass Creek mines.

The Wasatch or Weber mine is owned and operated by the Weber Coal Company, which is a part of the Ontario Mining & Milling Company of Park City. This mine is located about two miles northeast of Coalville, and is working a vein of ten feet in thickness. The output of the mine is about 300 tons per day. This property is composed of some two hundred acres of coal land.

The Rees-Grass Creek Coal Company is developing a mine one mile west of the Union Fuel Company on a lease from the Union Pacific Coal Company. The output is about 100 tons per day. The market for the Weber region coal is mainly Park City, and the cement plant located at Devil's Slide.

The upper, or small vein of this district is not being worked. Several openings have been made, and the coal proves to be of a fair quality, but the size of the vein is against it when it comes in competition with the larger veins.

This region is ideally adapted for large power plants. The coal is sub-bituminous and well adapted for steam purposes.

Out of the forty square miles of coal land in this region, lying within forty-five miles of Ogden and Salt Lake City

not more than one-tenth of the area has been acquired. Being located so near to the great central commercial cities of the State, where cheap power will be needed for manufacturing and electric railroad purposes, this region offers inducements for the investor who desires to develop the natural resources of the State along power plant and manufacturing lines. Not only is this fine grade of coal accessible, but there is also an ample supply of water in this locality for almost any purpose desired.

The Weber coal field possesses the three necessary features for manufacturing success, viz., cheap fuel, ample water and proximity to the commercial centers of the State, with an unexcelled climate at an elevation of 5,400 feet in addition.

Following is an analysis of various coals:

COAL ANALYSES.

Name of Coal	Moisture	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	B.T.U. Heat Units.
Weber	8.38	46.89	40.45	3.33	.95	11,694
Grass Creek	6.51	41.07	46.86	5.50	..	11,700
North Star	5.72	35.34	48.58	10.36	1.62	11,000
Consolidated Fuel	3.30	44.69	46.58	5.43	.63	13,200
Castle Valley	3.70	42.68	47.90	4.90	.82	13,213
Winter Quarters	8.10	40.21	45.91	5.78	.86	....
Castle Gate	4.72	39.13	48.45	6.73	.49	13.121
Clear Creek	7.02	41.89	45.80	5.29	.57	12,402
Old Aberdeen	4.95	40.45	49.00	5.60	..	13,170
Kenilworth	1.45	43.97	51.62	2.96	.749	13,480
Sunnyside	3.43	37.72	51.68	7.17	.78	13,000
Black Hawk	5.00	38.81	50.62	5.00	.37	12,550
Bear Gulch	5.19	43.89	46.91	4.01	.31	....
Horse Cayon	4.76	38.16	52.09	4.99	.74	13,500
Spring Canyon	1.8	43.40	52.20	3.6	.89	14,725
Johnson	2.4	41.20	53.30	3.10	..	13,241
Henry Mountains	11.3	38.03	46.38	4.46	.712	11,959

"Hiawatha" Nos. 1 and 2, Showing Mine Openings and Part of Tramroad.

TABLE SHOWING COAL PRODUCTION IN THE STATE OF UTAH FROM 1876 TO 1912.

Year.	Tons Produced.	Gain.	Loss.
1876	50,400	......	......
1877	50.400	......	......
1878	67,200	16,800	......
1879	225,000	157,800	......
1880	225,800	800	......
1881	250,000	24,200	......
1882	250,000	......	......
1883	250,000	......	......
1884	250,000	......	......
1885	213,120	......	36,880
1886	200,000	......	13,120
1887	180,020	......	19,980
1888	259,501	79,481	......
1889	236,651	......	22,850
1890	318,159	81,508	......
1891	371,045	52,886	......
1892	361,314	......	9,731
1893	418,049	56,735	......
1894	447,276	29,227	......
1895	172,958	......	274,318
1896	503,243	330,285	......
1897	582,092	78,849	......
1898	673,297	91,205	......
1899	878,122	204,826	......
1900	1,233,978	355,856	......
1901	1,382,470	148,492	......
1902	1,641,436	258,966	......
1903	1,782,178	140,742	......
1904	1,563,274	......	218,904
1905	1,602,528	39,254	......
1906	1,839,219	236,691	......
1907	1,967,651	128,432	......
1908	1,844,849	......	112,808
1909	2,322,209	467,360	......
1910	2,526,093	203,784	......
1911	2,501,471	......	24,622
1912	3,088,356	586,885	......

ASPHALT AND RARE HYDROCARBONS.

(By George W. Riter.)

Wide Range of Hydrocarbons in Utah.

It has been known for a long time that hydrocarbons of the rarer kind are found in Utah in greater variety, purity and extent than in all other parts of the world.

In the tabular classification of hydrocarbons, adopted by the U. S. Geological Survey and repeated below, we note comparatively few forms whose occurrence in Utah has not already been recorded.

Tabular Classification of Natural Hydrocarbons.

Gaseous:	Marsh gas Natural gas
Bituminous: Fluid	Naphtha Petroleum
Viscous	Maltha Mineral tar Brea Chapapote
Elastic	Elaterite Wurtzilite
Solid asphaltic	Albertite Impsonite Grahamite Nigrite Uintaite (Gilsonite)
Coal	Lignite Bituminous coal Semi-bituminous Anthracite
Resinous:	Succinite (Amber) Capolite Amboite, etc.

Cereous (waxy):	Ozocerite Hatchettite, etc.
Crystalline:	Fichtelite Hastite, etc.

BITUMEN AND ASPHALTUM.

It will be observed that some of the commonest terms in daily use, "asphalt" and "asphaltum," have been omitted from the foregoing table. "Bitumen" also is a term that has been omitted from the table, although its adjective, "bituminous," is employed. The use of the word "bitumen" is generic rather than special, and for all practical purposes it is synonymous with "asphaltum," both of these words being applied to the series of pure or nearly pure substances ranging from fluid petroleum to solid minerals. The use of the name "bitumen" for the whole series has the sanction and authority of long usage, although not sufficiently comprehensive for scientific purposes. The term "asphalt" seems to have been reserved for the solid forms.

Of the bituminous substances named in the foregoing table, some of them are considered only incidentally because they are intermedite in the series of substances between fluid petroleum and solid coal. Petroleum, which is carbon in combination with a maximum of hydrogen, stands at one end of the series, and anthracite, or nearly pure carbon, at the other end. Between these two extremes the other substances seem to stand as intermediate terms. They differ from one another in their chemical composition and in resistance to solvents, as well as in their physical texture and in their behavior when heated.

In the beginning, most of these substances were only mineralogical curiosities, but little by little they are becoming the basis of a considerable trade and industry. Their occurrence in Utah is reported at length in a paper by George H. Eldridge on "The Asphalt and Bituminous Rock

Deposits of the United States," in the Twenty-second Annual Report of the United States Geological Survey, 1900-01.

UINTAITE OR GILSONITE.

In commercial purposes, Uintaite, known more commonly by the trade name of gilsonite, is at the head of the list. During the year 1910 the production of gilsonite in Utah amounted to 27,547 tons, nearly all of which was shipped to Chicago to be manufactured into varnishes, paints, insulating material, waterproofing material, cements for roofing, etc. The principal producing mines were listed in the first preliminary report of the Conservation Commission.

SUBSTITUTES FOR RUBBER.

Many efforts are being made to produce substitutes for rubber from some of the natural hydrocarbons. Wiedgerite, or mineral liver, and tabbyite are new asphaltic minerals not on the foregoing list, which occur in Utah. They are similar to elaterite, but contain high percentages of sulphur, and are said to be especially valuable for the manufacture of rubber substances.

ROCK ASPHALT.

Besides the series of fluid, semi-fluid and solid bitumens, all of them in nearly pure condition, Utah has extensive natural formations of mechanically mixed bitumen with sandstone, limestone and earthy matters, constituting a class of substances which have important technical uses. Of these, probably the best known are asphaltic sandstones of Carbon county, Utah county and Wasatch county. These deposits are now being investigated in a preliminary way by the United States Geological Survey, with assurance that an exhaustive study and report will be made as soon as an appropriation is available for the work.

These rock asphalt deposits are beginning to assume merited importance because of the suitability of the material

for street paving and as top dressing for macadam roads. For these purposes, the material is the most desirable known, being a product of nature's laboratory, in which every grain of sand is thoroughly coated with pure bitumen whose permanent cementing strength and elasticity has already been tested by ages of exposure to heat, frost, moisture and other agencies. When properly laid, the material is like sanded rubber and outlasts granite blocks.

The following is a list of some of the more important rock asphalt deposits in Utah, and the names of their owners. For purposes of publicity, these owners constitute the Utah Rock Asphalt Association, with offices in Salt Lake City:

Carbon county, near Sunnyside—Utah Asphalt Co.
Carbon county, near Sunnyside—Williams & Burton.
Carbon county, near Colton—Clemens and Munz.
Wasatch county—Taylor and Richards.
Utah county, near Thistle Junction—B. F. Smith.
Utah county, near Thistle Junction—J. C. Benedict and C. S. Needham.

Publications Relating to Hydrocarbons in Utah.

Uintaite, Albertite, Grahamite, and Asphaltum, described and compared, with observations on bitumen and its compounds. Trans. Am. Inst. Mining Engineers, Vol. XVIII, pp. 563-581, Feb., 1890.

Oil and Asphalt Prospects in Salt Lake Basin, Utah. By J. M. Boutwell. In Bulletin 260, U. S. Geological Survey, pp. 468-479.

The Asphalt and Bituminous Rock Deposits of the United States. By George H. Eldridge. Twenty-second Annual Report, U. S. Geological Survey; 1900-01; Part I, pp. 209-464.

Origin and Distribution of Asphalt and Bituminous Rock Deposits in the United States. By G. H. Eldridge. In Bulletin 213, U. S. Geological Survey (1903); pp. 296-305.

The Modern Asphalt Pavement. By Clifford Richardson. New York, 1905; pp. 201-247.

Asphalt, Related Bitumens and Bituminous Rock. Mineral Resources of the United States; Annual Review. U. S. Geol. Survey. 1907; Part 2; pp. 723-730. 1908, Part 2; pp. 705-715. 1909, Part 2; pp. 731-733. 1910, Part 2; pp. 833-839.

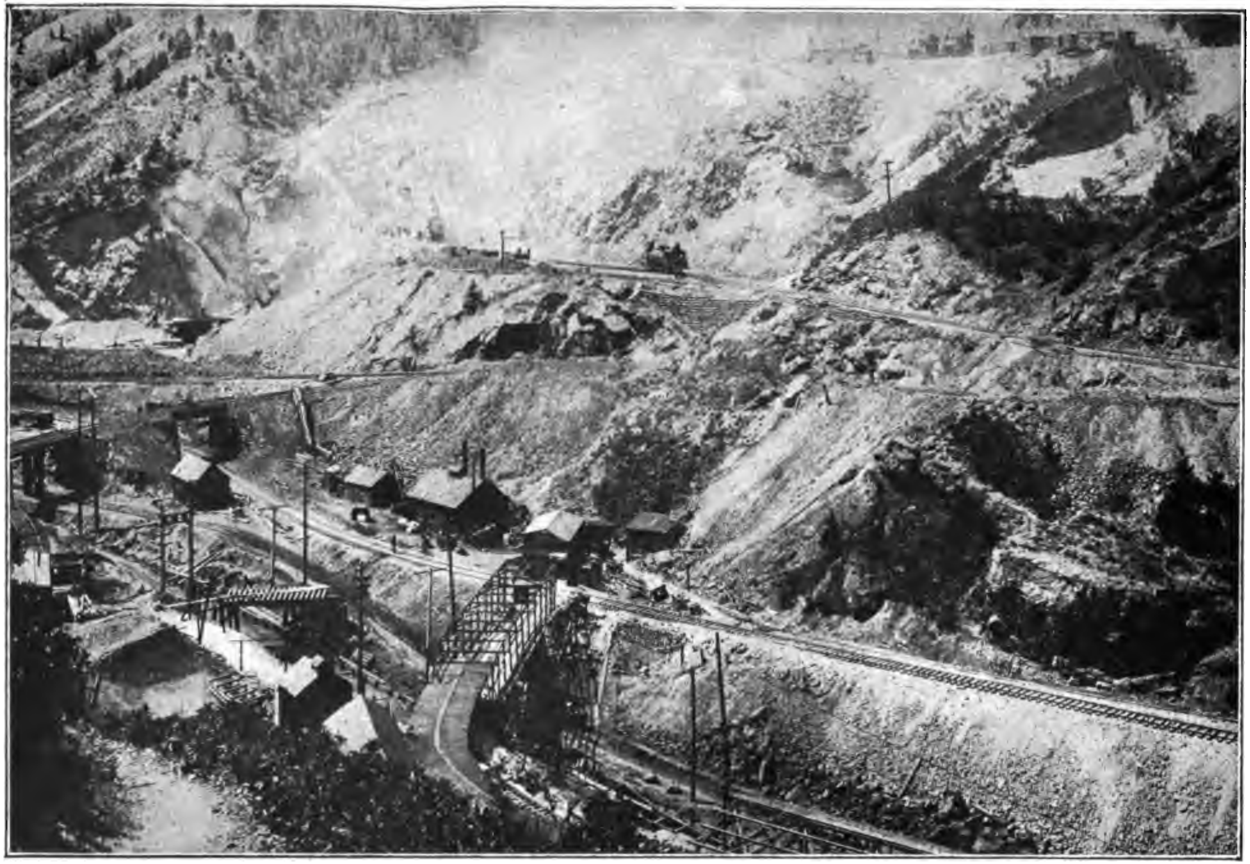
Asphalts; Their Sources and Utilizations. By T. Hugh Boorman. New York, 1911.

EARLY MINING IN UTAH.

It was in the latter part of 1863 that General P. Edw. Connor, the commander of the United States troops at Camp Douglas, made the first move toward the opening of the Utah mines. The Mormon pioneers who arrived in Salt Lake valley in 1847, fully realizing their isolated condition, had turned their attention to those industries requisite for making the people self-sustaining. Among their temporal pursuits agriculture was exalted as the basis of their prosperity, with home manufactures next. Iron and coal mining was encouraged, but not other mining, although evidences were not lacking that the mountains of the Territory treasured much gold and silver, as well as lead, zinc and copper.

It was during the first year of General Connor's sojourn in the Territory that he, while enjoying a picnic party in Bingham Canyon along with other officers of Camp Douglas, located the first mine in what was to become one of the greatest mining States of the Union. This mine he named the Jordan. Other claims were soon located in Bingham and General Connor wrote up some mining laws which were adopted at a miners' meeting held at Gardner's mill on the Jordan River, where the district was named the West Mountain Mining District, and Bishop Archie Gardner was elected recorder. Thus was the first mining district organized in the Territory.

In the Wasatch mountains the first discovery of ore was made in Little Cottonwood Canyon by General Connor, in the summer of 1864, but it was 1868 before the Little Cottonwood Mining District was organized. Not much was done in the development of these districts until the coming of the railroad across the continent. True, much money was expended by Connor and his California friends in exploiting the claims and building furnaces at various camps, but owing to unfavorable conditions, including the inexperience of workmen, the efforts failed.



Open Cut Mining and Switchback Tracks in Utah Copper Mines at Bingham.

The first shipment of ore from Utah was made in the summer of 1869. It was galena ore from the Emma mine of Little Cottonwood, and was shipped to the Selby Smelter of San Francisco. Many rich shipments followed, including a lot of forty tons from the East Canyon, now the Ophir District, in the Oquirrh mountains, shipped west by Walker Brothers, which netted $24,000. The success of these ventures gave an impetus to mining all over the Territory. From the summer of 1869 to the fall of 1871 ten thousand tons of silver and gold ores, valued at $2,500,000; four thousand and five hundred tons of gold and silver bearing bullion worth $1,237,000, and two hundred and thirty-one tons of copper ore valued at $6,000, were shipped from the Territory.

In 1868 the number of mining districts in the Territory was two; in 1871 there were 32. In 1911 the number of mining districts in the State had increased to 88.

The completion of the Utah Central Railroad in the spring of 1870, with its extensions later into Bingham, Little Cottonwood and American Fork canyons, did much toward the development of the mining industry.

From the advent of the railroad until the present there has been a healthy consistent growth in this important industry in Utah. The State's present prominence in mining has been gained gradually, and as a result of extensive development of enormous medium and low grade deposits. There have been few spasmodic and temporary gains in her metallic output, neither have there been any serious losses, as the years of prosperity and adversity in mining arrived Her advance has been rapid but regular, and the prospects are brighter now for increased output in future years than they ever were before.

The dividends from Utah's mines and smelters indicate the substantial nature of these industries. For 1911 the reported dividends amounted to practically $9,000,000, with prospects for greater dividends for 1912.

For the year 1908 Utah ranked third in lead, fourth in silver and copper, and fifth in gold among the States of the Union.

For the year 1911 the State ranked first in silver, fourth in copper, fifth in gold and third in lead.

The value of the mine output of gold, silver, copper and lead of Utah and the States immediately surrounding her for the year 1911 was as follows: Utah, $36,837,457; Colorado, $32,418,218; Nevada, $33,952,529; New Mexico, $2,704,843; Idaho, $19,100,698; Wyoming, $34,407; California, $25,174,677.

The known total output of these four metals in the State up to date has reached $503,000,000.

But mining in Utah is yet in its infancy. Mother Nature has shown us great favor during the geological history of our State in the operation of her dynamic forces, that have folded and faulted the rock layers of this portion of the earth's crust, bringing to the surface and hence within the ready access of man, layers and deposits that could otherwise be reached only by miles of vertical excavation. What treasures are stored up in our mountains has scarcely begun to be known. Recent developments in many camps have revealed phenomenal ore bodies. The Tintic district, for example, has long been producing an enormous tonnage of smelting ores; but during the past few years the new mines about Godiva Mountain have discovered extensive bodies of excellent ore, and the older producers of Tintic are showing richer values and larger ore bodies with increased development. Some of these properties are now worked to a vertical depth of nearly a half mile.

But Tintic is no exception, for Park City, the famous silver-lead camp, was never looking better than now, and as for Bingham—her resources are considered one of the wonders of the mining world.

The tremendous ore supply from the three camps above mentioned, along with that of many other important Utah camps, as well as the mines of Nevada, Idaho and even

Outcroppings of Iron Ore.

California, has justified the building of mammoth smelting plants in Salt Lake valley, so that Salt Lake City is at present the most important smelting center in the world. These smelters with their competition for custom ores are giving very favorable smelting rates to the ore producer.

Some of the more important mining districts of the State will be considered elsewhere in detail.

ORE DEPOSITS OF UTAH.*

The ore deposits of Utah are in the main confined to the western part of the State. They begin near the southwest corner of the State; thence the line between the productive and the barren region trends north-northwest, and in the latitude of Utah Lake and Salt Lake follows the crest of the Wasatch range. The extreme northern part of the State, adjoining Idaho, contains few deposits. In the eastern region lie a few deposits of copper and rare metals in sandstone, on Grand river a few iron deposits and the gold-bearing district of the La Sal mountains, near the Colorado boundary line.

The distribution of the districts corresponds to the two geologic provinces into which the State is divided. The unproductive area lies in the plateau province, in which paleozoic, mesozoic and tertiary strata are almost horizontal and igneous intrusions are generally absent. The ore-bearing area corresponds to the eastern part of the Great Basin, which is characterized by northward-trending ranges separated by desert plains. These ranges are built up of a thick series of paleozoic sediments similar to that of eastern Nevada. Along the Wasatch range triassic, jurassic and cretaceous rocks are also present. A typical section of the sedimentary strata comprises 10,000 or 12,000 feet of Cambrian quartzite, 1,500 feet of silurian limestone, 1,250 feet of Devonian quartzite, 10,000 to 15,000 feet of carboniferous limestone and quartzite, and finally about 5,000 feet of upper-

*By Waldemar Lindgren, U. S. Geological Survey.

most carboniferous (permian) or triassic shales, sandstone, and limestone, the upper portion of which grades into the mesozoic and consists in part of "red beds." In these folded and faulted sediments are numerous intrusions of granodiorite and quartz monzonite, and in places they are covered by tertiary-flow rocks, like andesite, latite and rhyolite. The largest area of intrusive rock is in Cottonwood canyon, in the Wasatch range, but even this is of comparatively small dimensions. The largest area of lavas is that of Beaver and adjacent counties in the southern part of the State, and this covers several thousand square miles. Toward the west it is continued across the Nevada line in the direction of Pioche.

The intrusive rocks are of post-Jurassic age; probably most of them date back to the late cretaceous, but there is also reason to believe that granular rocks were intruded during early tertiary time into some of the lofty volcanoes which at that time were situated in front of the Wasatch range. The effusive rocks—the lavas—began to pour out early in the tertiary period, and the maximum stage of their eruption falls in the later part of that period, though the basaltic eruptions which followed the andesite and rhyolite continued well into quaternary time.

No pre-Cambrian ore deposits are known in Utah. As elsewhere the ores are, in a broad way, divided into those of cretaceous age connected with intrusive rocks and those contained in lavas of late tertiary age. Owing to the presence at some places of early tertiary intrusions into volcanic cones, the line between these two classes is here and there difficult to define strictly.

Contact-metamorphic deposits carrying copper and some gold have been noted in the Frisco district, Beaver county; at Clifton, Tooele county; and in Cottonwood canyon, Salt Lake county. Copper deposits allied to them are also found at Bingham. Replacement deposits of silver-bearing galena occur in many districts and are as a rule intimately connected with fissure veins. Examples are furnished by the

districts of Park City, Tintic, West Tintic, Cottonwood, American Fork, Frisco, Star, Fish Springs and Willow Springs. Replacement deposits of copper ores in limestone are worked at Bingham and Tintic. Copper ores disseminated in monzonite and accompanied by tourmaline are mined at the Cactus mine, in the Frisco district. Gold-bearing replacement deposits of limestone are mined on an extensive scale at Mercur, in the Oquirrh range, and appear to be genetically connected with intrusive sheets of porphyry.

Gold and silver-bearing fissure veins in or near intrusive rocks occur at many places, among which may be mentioned Bingham and Tintic, but they do not contribute a large share to the gold production of the State. At Bingham there are widespread impregnations of cupriferous pyrite, and its enrichment by chalcocite deposited by descending solutions has given rise to the great low-grade copper deposits now worked by open-cut methods.

Placers derived from veins and other deposits connected with intrusive rocks have yielded a small production in Utah. Such gravels have been worked at Bingham, in the La Sal mountains, and along San Juan river.

Veins formed during the volcanic activity in middle tertiary time occur mainly in andesites and rhyolites and carry chiefly gold and silver; the principal localities are in the Kimberly, Mount Baldy and Ohio districts, in the volcanic center situated in Piute county; similar veins are found in the Stateline district, bordering on Nevada, in Iron county.

Differing from all the preceding types are the metal-bearing sandstone ("red beds") of the plateau province. They show no evidence of genetic connection with igneous rocks. Silver and copper ores of this kind have been mined at Harrisburg (Silver Reef), in Washington county, and similar copper ores in sandstone are reported from Uinta county, in northeastern Utah. Vanadium and uranium ores occur on Grand river near the Colorado line.

Some quicksilver is found in the gold ores of the Mercur or Camp Floyd district, from which some production of this metal has been reported, and a selenide and a sulphoselenide of mercury occur in veins of the Ohio district, near Marysvale.

Iron ores are found at several points. In the Iron Springs district, Iron county, and at Bull Valley, Washington county, are considerable bodies of magnetite in deposits of contact-metamorphic origin, between porphyry and limestone. A hematite deposit in carboniferous limestone occurs at Rhodes Plateau, in Summit county, in the Uinta mountains. Brown iron ores in small masses are not uncommon. One of these deposits, contained in probably mezozoic sandstone, occurs in the northeast corner of the State near Vernal.

UTAH'S METAL OUTPUT FOR 1911.

The value of the mine output of gold, silver, copper, lead and zinc in Utah in 1911, according to Victor C. Heikes, of the United States Geological Survey, was $36,837,457, against $32,199,185 in 1910.

The total gold production in Utah in 1911 was 227,217.28 fine ounces, valued at $4,696,998, against 195,052.11 ounces, valued at $4,032,085, in 1910, an increase in value of $664,913, or over 16 per cent. The largest producer of gold was Salt Lake county, which yielded $2,284,934, against $1,776,058 in 1910. The West Mountain or Bingham district produced $2,281,943 of the gold credited to Salt Lake county and over 48 per cent of the total Utah gold output. The Tintic district, which is partly in Juab county and partly in Utah county, produced $1,592,052, or 33 per cent of the total output.

The silver production of Utah in 1911 showed an increase from 10,466,971 ounces, valued at $5,652,164, in 1910, to 12,473,787 ounces, valued at $6,611,107, in 1911. The Tintic district yield of silver increased from 5,222,742 ounces in 1910 to 5,514,702 ounces in 1911. Of the Salt Lake county yield the West Mountain or Bingham district contributed

1,800,410 ounces in 1910 and 2,786,810 ounces in 1911. The silver output of the Park City mining district in 1911 was 3,428,651 ounces, an increase of 856,880 ounces, or over 33 per cent, from that of 1910.

Copper production increased in Utah from 127,597,072 pounds in 1910 to 146,960,827 pounds in 1911, an increase of 19,363,755 pounds. The Bingham district produced 129,-995,865 pounds of copper in 1911, against 113,725,280 pounds in 1910, 92,560,340 pounds in 1909, 71,155,740 pounds in 1908 and 45,431,964 pounds in 1907. The Tintic district yielded 10,922,154 pounds in 1911, against 8,993,036 pounds in 1910, an increase of 1,929,118 pounds. The Park City district, in Summit and Wasatch counties, produced 1,281,190 pounds in 1911, against 1,423,629 pounds in 1910.

The production of lead in Utah in 1911 was valued at $6,142,354, against $5,426,284 in 1910. Of the 1911 output, nearly 35 per cent was derived from mines in the Park City district, which produced 47,637,642 pounds, against 38,129,761 pounds in 1910. The Bingham or West Mountain district produced 46,576,337 pounds in 1911, or 34 per cent of the total Utah lead output, against 30,271,016 pounds in 1910. The Tintic district, which yielded 37,553,455 pounds of lead in 1910, produced only 23,572,966 pounds in 1911.

The production of zinc in Utah in 1911 was 17,840,261 pounds, valued at $1,016,895, against 16,367,104 pounds, valued at $883,824, in 1910. This shows an increase of 1,473,157 pounds, or 9 per cent. The Park City mining district alone produced 8,596,564 pounds of zinc in 1911, and the Bingham district 4,715,121 pounds.

The zinc in concentrates, amounting to 13,156,682 pounds, all came from Salt Lake, Summit and Wasatch counties.

There were 208 mines producing gold, silver, copper, lead or zinc in 1911, against 183 in 1910. The total quantity of ore sold or treated in Utah in 1911 was 7,268,530 short tons, an increase of 879,132 tons. The average total recoverable value per ton was $5.07 in 1911, against $5.04 in

1910. The average value per ton is low on account of the large tonnage of copper ore, of which 6,121,099 tons were sold or treated.

Of the total ore of all classes 267,111 tons went to gold and silver mills, 5,840,091 tons to concentrating mills, and 1,103,054 tons to smelters.

The Following Table, Prepared by V. C. Heikes of the Geological Survey, Shows the 1911 Mine Output of Metals in Utah by Counties.

County.	Gold		Silver.	Copper	Lead.	Zinc.	Total Value.
	Placers	Deep mines	Fine ounces	Pounds	Pounds	Pounds	
Beaver	....	$ 47,568	201,259	3,739,282	4,534,678	64,927	$ 829,406
Boxelder	....	6,210	2,291	289,769	70,385	....	46,812
Garfield	$1,079	823	20	....	....	....	1,913
Grand	.....	2	360	342	236	....	247
Iron	.....	1,794	1,012	3	....	....	2,332
Juab	.....	1,500,359	4,673,698	10,927,100	15,015,484	11,359	6,019,651
Millard	.....	1,214	905	1,411	15,155	....	2,552
Morgan	.....	6	149	....	16,890	....	845
Piute	.....	25,968	5,393	7,816	....	....	29,803
Salt Lake	.....	2,284,934	2,947,481	130,412,972	47,647,390	4,715,121	22,561,615
San Juan	1,075	....	12	....	....	....	1.081
Sevier	.....	133	1,291	....	....	....	817
Summit	.....	80,538	2,882,825	961,122	37,736,908	7,292,774	3,842,424
Tooele	.....	584,917	276,485	293,106	11,746,797	4,452,290	1,550,479
Uinta	3,480	....	12	....	....	....	3,486
Utah	.....	135,232	934,768	7,836	9,812,093	....	1,073,182
Wasatch	.....	21,666	545,826	320,068	9,900,734	1,303,790	870,812
Total	$5,634	$4,691,364	12,473,787	146,960,827	136,496,750	17,840,261	$36,837,457

SILVER CITY SMELTER, TINTIC DISTRICT.

The Smelter has four lead blast furnaces, with daily capacity of 250 tons each, and one copper furnace, with daily capacity of 250 tons. Necessary equipment to increase the capacity of the copper furnace to 500 tons daily is at the works ready to be installed.

SALT LAKE CITY AS A SMELTING CENTER.

Salt Lake City as a smelting center unquestionably offers more advantages to the ore producer than any other market in the smelting world. Owing to the varied interests controlling the industry, keen competition exists at all times. In addition to this favorable condition, the shipper has for his convenience the use of public sampling mills located at strategical points in transit, the object of which is to produce a sampling result equally satisfactory to the shipper and purchaser. The Utah Ore Sampling Company, handling the public sampling business of the State of Utah, operates mills at Murray, Silver City, Sandy and Park City, with a total daily capacity of three thousand tons.

A ready market is not only found here for the widely diversified ores of the commoner varieties produced throughout Utah and surrounding States, but the producer can here find an outlet for the rarer metals, such as uranium, tungsten and vanadium.

With improved methods of recovery, combined with favorable market conditions and increased competition, many mining properties practically abandoned have returned to very active productivity, being enabled to handle ores of exceedingly low grade. This revival of production from the older properties, together with increasing tonnages from newly discovered fields, has been the means of encouraging the investment of large capital in new plants and widening the scope of operations of the older smelting companies.

There are now operating smelters with capacities as follows:

	Tons Daily
American Smelting & Refining Co., Murray Plant, Lead	1,500
American Smelting & Refining Co., Garfield Plant, Copper	3,500
United States Smelting Co., Midvale, Lead	1,000
United States Smelting Co., Midvale, Copper	1,500
International Smelting & Refining Co., Tooele, Lead	1,000
International Smelting & Refining Co., Tooele, Copper	1,500
Total daily capacity	10,000

The United States Smelting, Refining & Mining Company is operating, in connection with the concentrating plant at Midvale, Utah, a fifty-ton plant equipped with Huff electrostatic machines. The lead-zinc ores from the company's Bingham mines, treated in the concentration plant, yield lead concentrates and middlings, the latter carrying 22 per cent zinc as well as some lead and pyrite. The middlings are passed through the Huff machines, yielding a 53 per cent zinc concentrate and a high-grade pyrite product carrying the gold, silver and lead. The pyrite product is utilized at the lead smelter at Midvale.

BINGHAM.

Mining Deposits.

As a preface to the consideration of some of the larger mines of Bingham, we quote from the summary of the geology of this area in the Monograph on Bingham by the United States Geological Survey: "Between carboniferous and late tertiary time monzonite intrusives invaded sediments in the Bingham area, metamorphized them, and introduced metallic elements which replaced marbleized limestone with pyritous copper sulphides. After the superficial portions of the intrusives had cooled to at least partial rigidity, they and the enclosing sediments were rent by persistent northeast-southwest fissures.

"Heated aqueous solutions from below then ascended, producing alterations and introducing metallic minerals. Later the original sulphide ores, altered by surface waters, were oxidized in the upper layers, and secondarily enriched below by changing to black copper sulphides with the addition of gold and silver."

As a result of this process of mineralization there is found in the camp three types of deposits, namely: (1) the disseminated ore of the monzonite laccolith and the contiguous quartzite; (2) the sulphide lode or vein ores; and

(3) the replacement or bed ores in limestone. The first type is known in the district as "porphyry ore," and the others as the "sulphide ores," since they contain pyrite or iron sulphide as the predominating mineral. Important mines are now producing from each of these classes of ores.

THE UTAH COPPER COMPANY.

The State of Utah has the distinction of having within its borders the largest copper mine in the world. This mine is situated in Bingham Canyon, and is the property of the Utah Copper Company. This company owns 724 acres of ground in the heart of Bingham, and on 214 acres of this ground they have fully and partially developed 301,500,000 tons of ore; and there are good mining assurances that they will develop a considerable tonnage of profitable ore in the 483 acres not yet developed.

The company also owns 1587 acres of land near the mouth of Bingham Canyon, and 3358 acres at Garfield.

The average assays of the 301,500,000 tons of fully and partially developed ore is 1.532 per cent copper. This ore also contains a small amount of gold and silver. In obtaining the average assay, there were used 38,824 assays, representing 14,035 feet of diamond drill holes and churn drill holes, and 246,900 feet of drifts, raises and winzes, or a total of 260,935 linear feet of development.

During the year 1911 the company mined and milled, 4,680,000 dry tons of ore, and during the year 1912 they expect to mine and mill about 6,000,000 tons of ore. They are increasing the capacity of their mills to 20,000 tons of ore per day so that they expect to mine about 7,300,000 tons per year; and it is safe to say that the Utah Copper Company will be producing copper for the next fifty or sixty years at the rate of about 150,000,000 pounds of copper per year.

During the year 1910 the Utah Copper Company acquired the mines and property of the Boston Consolidated Mining Company and of the Shawmut Consolidated Mining Company.. By acquiring these two properties it gave them

one solid block of lode claims with no interior ownership by others, and added over 500 acres of mining ground to their property.

The ore bodies of the property in central Bingham consist of an altered siliceous porphyry containing small grains of copper minerals, very uniformly disseminated throughout the mass. The primary copper mineral is chalcopyrite, but as a result of secondary enrichment from above, practically all of the copper sulphide minerals are now present.

EQUIPMENT AT THE MINES.

The equipment at the mine consists of 22 standard gauge steam shovels, 35 standard gauge switching locomotives, 1 standard gauge Shay locomotive, 11 narrow gauge switching locomotives and 365 cars. There are also 11 churn drills used in drilling for development and blasting purposes. This equipment is all used on the surface for stripping the ore bodies and mining the ore.

Under ground it has electric locomotives and the necessary cars for haulage.

METHOD OF MINING.

About 78 per cent of the ore mined by this company is done by steam shovels, and about 22 per cent is being taken out by the underground caving system.

The average cost of mining all the ore obtained both from surface and underground operations during the year 1911 was 44.79 cents per ton, of which 12.81 cents was charged to cover prospecting with churn drills, underground development and stripping expense, leaving a net cost for actual mining, including general and fixed charges, of 31.98 cents per ton.

It is the purpose of the company to discontinue underground mining as soon as possible. When all their mining is done by steam shovels their cost of mining will be about 25 cents per ton.

CONCENTRATING PLANTS.

The company has a capacity in their milling plants at Garfield of 20,000 tons per day. The Magna mill will handle 12,000 tons, and the Arthur mill 8,000 tons per day.

These plants represent a large expenditure by the company, and are equipped with the best and most modern concentrating machinerq. The Magna plant was originally designed to treat 6,000 tons of ore per day in its 12 sections; the management, however, has increased the capacity of this plant to 12,000 tons per day by installing Garfield roughing tables and other modern appliances. This plant contains 1104 Johnson concentrating machines and 48 Wilfley tables.

The process of concentrating consists in crushing all of the ore fine enough to liberate the valuable minerals from the waste particles.

The concentrates average about 25 per cent copper and between $5.00 and $6.00 in gold and silver.

These concentrates are smelted by the Garfield Smelting Company at their smelter at Garfield.

A modern power plant of 8,000 kilowatt capacity is also operated in connection with the Magna mill. Power is also delivered from this plant to the mines in Bingham over the company's own power lines.

It also has two large concrete reservoirs with a capacity of 3,500,000 gallons of water.

BINGHAM & GARFIELD RAILWAY CO.

The company owns its own railroad connecting the mines and the mills. In order to insure a steady and continuous supply of ore at its mills, the company constructed the Bingham & Garfield railway, which runs between the mines at Bingham and the mills at Garfield, a distance of 20 miles. The stock of this road is entirely owned by the Utah Copper Company.

Its equipment consists of 4 Mallet locomotives, each weighing 460,000 pounds on the drivers; 8 switching loco-

motives, each weighing 122,300 pounds on the drivers; 250 hopper bottom steel ore cars, each having a capacity of 132,000 pounds net load; together with the necessary tool cars, cabooses, flat cars and passenger coaches; and it has at present 150 new ore cars under construction. When all of this equipment has been received it is expected that the road will handle about 15,000 tons of ore per day.

Passenger service is also maintained between Salt Lake City and Bingham via Garfield. This passenger service is run in connection with the Salt Lake Route. The passenger equipment is furnished by the latter company, and two trains each way leave Salt Lake and Bingham every day, the terminus in Salt Lake being the San Pedro depot.

The road is noted for its mountain scenery, and is becoming very popular for tourist visitors to the camp. By taking this road the tourist can see the town of Garfield with its smelters and concentrating mills, the Bingham Canyon with its great mines all in one day.

The road has four tunnels having an aggregate length of 4798 feet. These tunnels are located in the first three miles of line from the Bingham end. In that distance there are also three steel bridges, containing about 3,000 tons of steel and having an aggregate length of 2,000 feet. The maximum heights of these bridges, beginning with the one across Carr Fork at the upper end of the line, are 190, 225 and 188 feet respectively. The main line between the mines at Bingham and the mills at Garfield is laid with 90 lb. steel. The line was put into operation on the 15th day of September, 1911.

The heavy Mallet compound locomotives readily handle a train of 40 ore cars, containing 65 net tons each of ore, a net train load of 2600 tons between the mine and the mills at Garfield in 1 hour and 30 minutes.

The Utah Copper company employs in its mines, mills and railway about 4500 men, with a monthly payroll of over $400,000; and the monthly disbursements of this company amount to considerably over $1,000,000 per month.

The company has paid out in dividends to date $14,063,897.50. Its dividends are being disbursed quarterly at the rate of 75 cents per share per quarter, and at the present time it is estimated that it is earning better than $5.00 per share per year.

To the vice-president and general manager of the company, Mr. D. C. Jackling, is largely due the development of this wonderful property. Through his great ability he has brought to the front an industry that is directly or indirectly contributing to the support of at least 10,000 people; and has raised the State to fourth in point of copper production in American commonwealths.

SMELTING THE CONCENTRATES.

The concentrates from the monzonite ore form a very desirable smelting mixture. It may be smelted direct in the reverberatory furnace or roasted preliminary to smelting. The fine concentrates containing high sulphur values are roasted in pot furnaces or in mechanically rabbled furnaces for the partial elimination of the sulphur. If the pot furnace is used the roasted product is in a sintered but porous condition for the copper blast furnace. Matte and slag are run from the blast furnace continually and these separate from each other by gravity in a large settler. The slag with less than .5 per cent copper is discarded, and the matter is further treated to obtain metallic copper. When the fine ore is roasted in the mechanically rabbled furnace (the McDougal) and taken out in a loose powdery condition, the reverberatory furnace is employed to smelt the roasted material. Furnaces with upwards of 2,000 square feet hearth area are employed at the Garfield smelter on this fine, powdery material, and 350 tons of this roasted ore are run through each furnace each 24 hours. The products of the reverberatory furnaces, like the products of the blast furnaces, are slag and copper-iron matte.

The slag from both kinds of furnaces is run into large pots arranged on trucks, and transferred by locomotive on

tracks to the slag dump, where it is run out in a molten state as waste.

The matte from the settler of the blast furnace or from the reverberatory furnace is run into ladles of 10 tons capacity, operated by electric traveling cranes, which span the converter house. At the Garfield works there are two such cranes, each of 60 tons capacity, which run the full length of the converter building. The ladles of molten matte are quickly carried to the converter and the contents poured in and the ladle returned for more matte. When the converter has received its charge of ten tons the air under a pressure of 12 pounds is turned on and the shell is tilted back to position. When the blow begins there is rapid oxidation of iron and sulphur. The iron having the stronger affinity for oxygen is finally all oxidized, forming with the siliceous converter lining an iron silicate slag. The slag is then skimmed and the remaining copper sulphide, after being replenished by the addition of molten sulphide of the same copper content from other converters, is again blown, to oxidize the remaining sulphur and produce metallic copper, 98 per cent pure, known as blister copper, carrying the gold and silver that were in the original ore. The bars of copper bullion cast from the converter are 24 inches long by 18 inches wide by 2 inches thick and weigh 300 pounds.

The metal is shipped away to the refineries in this crude condition. As the centers of consumption of the refined products are at a great distance from the smelting plant and as the costs of transportation of the refined metals is much greater than that for crude bullion, no effort is made at refining the bullion in Utah.

THE UNITED STATES MINING COMPANY.

The properties of the United States Mining company in Bingham canyon include the Old Jordan, Galena, Telegraph and Niagara mines. These mines produce daily 1,000 tons of lead and copper ores containing small amounts of gold

and silver. The lead ores also contain zinc, which is now a recoverable metal, by means of concentration and static separation. The United States company's ores are conveyed over an aerial tram to Bingham and from there transported by rail, a distance of 12 miles to the company's smelter and concentrator at Midvale, near Salt Lake City. The lead ores are concentrated and the copper ores smelted direct. In concentration at Midvale two products are made from the lead ore—a lead concentrate, which is smelted, and a zinc-iron middlings which, in the electrostatic mill, is separated into iron and zinc products. The United States Mining company is a subsidiary of the United States Smelting, Refining and Mining Company of Maine.

UTAH CONSOLIDATED COMPANY.

The Highland Boy mine of the Utah Consolidated company was one of the early producers of the high grade sulphide ores. The ores of this company were smelted for a number of years at their own smelter at Murray, Salt Lake county. The ore averaged high in copper and the output of the smelter in copper bullion was large for the ore tonnage treated. The high grade ore and the favorable conditions of mining and smelting were indicated by the dividends disbursed. These have amounted to seven million and two hundred thousand dollars.

The Utah Consolidated company in the year 1910 made a long term contract for smelting its own ore with the International Smelting and Refining Company. This smelter is four miles distant from the mine and the ore is transported direct from the mine to the smelter by means of an aerial tramway.

The tonnage for 1911 amounted to 162,522 tons of copper ore, 8,305 tons of lead ore, and the product from this tonnage was 9,162,923 lbs. copper, 3,311,931 lbs. lead, 160,366 oz. silver, 16,730 oz. gold.

TINTIC MINING DISTRICT.

By Geo. W. Riter.

Tintic mining district is situated on both sides of the range of mountains that separates Juab county from Utah county. It is one of the oldest mining districts in Utah, and boasts the distinction of being the home of more separate dividend-paying properties than any other district in the west. Some of the mines now sending ores to market have been producing every year for forty years. The history of the district has been one of steady growth, rather than of leaps and spurts, and at the time of this writing (1912) more miners are employed and more tons of ore are being produced than at any time in the history of the district.

Mining operations in the district began in 1869, when ore was discovered in fissure veins in the monzonite zone in the south end of the district, near Silver City and in the neighborhood of the now deserted camp of Diamond. These fissure deposits were small, and only a few were profitable. Some of them are still being worked at intervals, but most of them are lying dormant.

In 1870 ore in the form of siliceous deposits within limestone formations was discovered at Mammoth and at Eureka. These pioneer discoveries in limestone were at the surface of the ground; but on developing the deposits at depth they were found to continue for thousands of feet—pinching, swelling, diverging, joining, twisting, and worming their way through the solid formation—not unlike strings of sausages. These deposits or chains of ore were sufficiently extensive to encourage deep shaft-sinking and deep drifting on many tracts that had no ore at the surface. Of ventures of this kind enough became profitable to encourage additional ones, and in this way there has been rounded out a long series of producing mines that now constitute an area rather than a belt.

A tabulation of the outout by mines, for any year, would contain the names of several dozen properties which produce in the aggregate over 300,000 tons per calendar

General View of Mine—Centennial-Eureka.

year. The deepest shaft on the west side of the district, at Eureka, belongs to the Centennial Eureka mine, the tonnage of which is the largest in the district, being in excess of 100,000 tons annually. This property is the largest single producer of copper and gold in the district. The deepest shaft on the east side of the mountain belongs to the Iron Blossom mine, which ranks second in the matter of tonnage, and is the district's largest single producer of silver and lead.

Generally speaking, the ores of the district are valuable for silver, lead, copper and gold, in the order named and all are now sent out of the district for treatment at smelting plants situated in the Salt Lake and Tooele valleys.

The district is served by the San Pedro, Los Angeles and Salt Lake railroad (the Salt Lake Route), which reaches Eureka, Robinson (Mammoth), and Silver City; and by the Denver and Rio Grande railroad, which reaches the same camps, and also the station of Summit. The Eureka Hill railroad connects at Silver City and runs around to the Dragon, Iron Blossom, Colorado and other mines on the east side of the mountain.

Metal Production of the Tintic District.

The steady growth of the Tintic district is evidenced by the increase in annual output of metals, as tabulated and reported each year by the U. S. Geological Survey. The figures given below are for each tenth year since the discoveries in 1870. The data for 1880, 1890 and 1900 are based on the most reliable estimates and tabulations for the district; those for 1910 are the tabulations of the United States Geological Survey.

Year.	Gold. Ounces.	Silver. Ounces.	Copper. Pounds.	Lead. Pounds.
1880	3,012	8,682	2,000	45,000
1890	24,633	3,801,700	900,000	20,000,000
1900	75,355	4,809,970	6,052,157	36,840,579
1910	66,289	5,222,742	8,993,036	37,553,445

Publications and Maps, Tintic Mining District.

Geology and Mining Industry of the Tintic Distric, Utah. By George W. Tower and George Otis Smith. 176 pages. Nineteenth Annual Report, U. S. Geological Survey; Part 3; 1899.

Later Studies of the Tintic District. U. S. Geological Survey. Now in preparation.

Mineral Resources of the United States. Annual Review; U. S. Geological Survey. 1905, pp. 317-320, 355. 1906, pp. 345-348, 407-409, 449. 1907, Part 1, pp. 447-452, 618-619. 1908, Part 1, pp. 217, 557-561. 1909, Part 1, pp. 172, 468-473. 1910, Part 1, pp. 209, 585-587.

Topographical and Geological Maps of the Tintic District. Folio 65, U. S. Geological Survey; 1900. Six maps, also text. Price 25 cents.

Tintic Mining Map. Size, 22 by 34 inches; scale, 800 feet to the inch. U. S. Geological Survey. Price 10 cents. On sale by local dealers in engineering supplies.

Tintic Special Map. Size, 16½ by 20 inches; scale, one mile to the inch. U. S. Geological Survey. Price 5 cents. On sale by local dealers in engineering supplies.

Tintic District; Map of Mining Claims and Property Groups. Collier and Knight, Salt Lake City; 1900. Size, 20 by 36 inches; scale 1000 feet to the inch.

Tintic District; Map of Mining Claims and Property Groups. Child, Cole & Co., Salt Lake City; 1909. Size, 22 by 34 inches; scale, 1400 feet to the inch. Free.

Tintic District; Assembled Map of Official Surveys. U. S. Surveyor-General, Salt Lake City. Scale, 400 feet to the inch. Blue printed in sheets 24 by 24 inches. Price 75 cents per sheet.

STEADY PRODUCERS.

The Centennial-Eureka Mining Company, a subsidiary of the United States Smelting, Refining and Mining Company, is the largest producer in the Tintic district. It ships daily, and has shipped for years past, an average of 300 tons of ore containing values in gold, silver, copper and lead. These ores are transported by rail to the United States smelter at Midvale. The Centennial-Eureka has been a consistent shipper in the past and is developed to an extent that without the uncovering of new ore bodies it can continue to ship at the same rate for many years to come. The Bullion Beck Mining Company, one of the old producers of the district, is now controlled by the United States company and is undergoing extensive development to open up ore bodies in hitherto unprospected ground.

PARK CITY DISTRICT.

Despite the tremendous tonnage production of the Park City mines, current authoritative reports lead to the inevitable conclusion that the properties there have been but partially sounded for their mineral wealth, and that the district is entering another production era which will surpass in earning quality the previous record of the camp. The principal properties of Park City are at the most favorable point in their history.

This condition is due to the enormous expansion of development work during the past two years, new ground and new depth affording new resources of great extent and value, while the various producers have been equipped up to the minute in order to keep pace with the underground disclosures.

Broadening the influence of the Ontario drain tunnel, so as to benefit a number of new sections of the district, has been one of the most striking features of the recent history of Park City. The chief beneficiary of this has been the Daly-Judge property, the company being now able to operate for the first time without any water trouble to as great a depth as 2500 feet. This has extended the development possibilities of the Daly-West, Thompson-Quincy and other propositions within the influence of the drainage system.

In the operations of the Snake Creek tunnel also will the properties of Park City be materially benefited, this deep bore coming into the district from the Snake Creek side of the divide so as to secure depth in virgin sections of the district, and to drain a very extensive area that operations may be conducted without the difficulty and expense now attaching to an entirely untouched and richly mineralized part of the district.

The Snake Creek tunnel will be driven for 15,000 feet to its first objective, and it is now completed for one-third this distance. This enterprise is being backed by the Daly-Judge company, the owner of one of the largest areas in the camp, and the Knight interests of Provo.

Production at an unusual rate is being maintained by such companies at the Daly-Judge, Daly-West and Silver King Coalition, the first two being in the regular quarterly dividend paying columns, while the latter is expected to resume dividends within the near future. The Silver King Coalition company recently completed the electrification of its entire property, and a high official is authority for the statement that the mine will more than equal its production and dividend record of the past.

The production of these companies consists of both high-grade crude ores and rich concentrates, all three keeping their concentrating plants continually in service, while the production of zinc ore and concentrates of the camp has been very materially increased as a result of the discovery of large bodies of this mineral and the increased market price of the product.

One encouraging feature of the recent Park City activity has been the number of valuable discoveries in the outlying sections of the camp, especially in the Thaynes canyon region on the way to Brighton. This is serving to encourage the resumption of operations by several companies and private owners of ground, with the result that new producers are being brought to light.

Operations are being carried forward by the New York Bonanza, Keystone, Copper Apex, Wabash, Silver King Consolidated, Thompson-Quincy, Daly, American Flag, Barry-Coxe and other organizations within the confines of the district.

This happy condition at Park City fortunately is coincident with a satisfactory metal market and ideal transportation and smelting facilities.

MERCUR DISTRICT.

Utah's great gold mining camp, Mercur, is situated in the Camp Floyd Mining district, Tooele county, about 60 miles southwest from Salt Lake City. It is reached by the San Pedro, Los Angeles and Salt Lake railroad, 50 miles

from Salt Lake City to Fairfield, and the Salt Lake and Mercur railroad, 10 miles from Fairfield to Mercur. The latter is a mountain railway, probably the crookedest in the world, with such features as a four per cent grade and forty degree curves.

The Mercur district is situated in the Oquirrh mountain range. There is a series of north and south ranges lying in the Great Basin, and the Oquirrh is the first of these so-called basin ranges lying west of the Wasatch mountains. The Oquirrh range is only about 30 miles long, and from five to ten miles in width. Besides Mercur, this range includes the other well known mining camps of Bingham, Stockton, and Ophir. The Tintic district might also be properly classed as belonging to the Oquirrh range, because the Tintic mountains are practically a southerly continuation of the Oquirrh mountains.

Where the town of Mercur now stands, in 1870-71 there was a busy silver mining camp. The Carrie Steele, Sparrowhawk, and other mines produced some wonderfully rich ore, and considerable excitement prevailed for a time. But the rich pockets were soon worked out, and as prospecting was not rewarded by other new discoveries, the camp was deserted and by 1880 had passed entirely out of existence. The recorded production of Lewiston amounts to only about 46,000 ounces silver, hence it cannot be said that it ever was an important producing camp. The presence of the gold ledges was not unknown during the Lewiston silver mining days; or, more properly speaking, they were not undiscovered. Prospectors in those days used to find an outcrop of yellow rock, which looked good enough to have assayed. Numerous assays gave returns of from $2 to $20 gold per ton. Upon getting a favorable return, the prospector in each case went back with his gold pan to pan some of the rock. As never a color was found, the assayer was pronounced an "Ananias," and it is said that more than one assayer was forced to go out of business in Salt Lake City because his record had become tainted with trickery and jobbery in giving good returns on this apparently worthless rock.

During the Lewiston days, cinnabar was also found in the Camp Floyd district. This is further evidence that the gold ledges were known at that period, for while cinnabar occurs in the silver ledge, it does not occur in quantities, as in the gold ledges. A report for the year 1871 states that "there is also a vein affording cinnabar of low percentage." The Government report on Mineral Resources makes fuller mention of cinnabar discoveries in the district, and states that a test made on a 100-pound lot of the ore gave an average of four per cent quicksilver. This was evidently considered too low grade for profitable handling, or else the statement was incorrect. At any rate, quicksilver mining was not attempted. A few years later, however, the deposit again attracted attention, and on April 30, 1879, Arie Pinedo located a claim on this cinnabar vein, naming it "Mercur," after the mercury in the ore. This claim he patented, and it subsequently became the nucleus of the gold camp, giving its name to the Mercur mine, as well as to the new camp, which in 1890 sprang up on the site of the defunct Lewiston.

From time to time, during the period between 1875 and 1890, stories were brought to Salt Lake City about the big vein in the Camp Floyd district which carried good values in gold. Experienced miners refused to give credence to the reports, because, as has been explained, no gold could be panned out of the ore. All efforts to interest capital proved fruitless. At length a number of Nebraska gentlemen, who had had no previous mining experience, and among whom was Mr. John Dern, now one of the most prominent mine operators of the West, were induced to go into a scheme to organize a company, and work the property, and in 1890 the Mercur Gold Mining & Milling Co. was formed. An amalgamation mill was built, but proved an utter failure. It appeared that the "Nebraska farmers" had been buncoed, and that their hard earned money had been foolishly wasted, when the timely introduction of the cyanide process turned failure into success. The camp soon became, and has ever since remained, a heavy producer and dividend payer. Up to this time it has yielded about $18,000,000 in gold.

After the Mercur Gold Mining & Milling Company had demonstrated its success, a typical mining boom sprang up in the Mercur district, which became known as the "Johannesburg of America." Among the properties that developed into paying mines were the Marion, Geyser, Golden Gate, Brickyard, Sacramento, Overland, Sunshine and Daisy. Most of these properties were equipped with mills and became dividend payers. The Golden Gate and Brickyard mines were bought by Capt. J. R. De La Mar, who equipped them with the famous Golden Gate mill, which at the time of its completion, in 1898, was the largest cyanide plant in the world. In 1900, the Mercur Gold Mining & Milling Company and De La Mar's Mercur Mines Company were merged into the Consolidated Mercur Gold Mines Company. This company, although its period of greatest prosperity has apparently passed, is still in operation, and is a steady producer of large quantities of the yellow metal. The company furnishes employment to about 300 men, besides distributing large sums of money each month for supplies. The ore has during the past few years been getting lower grade, and it is only through improved metallurgical methods and highly efficient and economical management that it has been made to pay. The company has paid $3,385,312.97 in dividends, including the amounts paid by the old Mercur and De La Mar companies. Mr. John Dern is president, and Mr. George H. Dern is general manager.

Mercur enjoys the distinction of being the pioneer cyanide camp in America. When other processes had failed, the cyanide process, which was then in its infancy, was tried as a last desperate resort. It proved to be just what was needed. The first plant was crude, but it turned failure into success, and improvements in methods and equipment soon followed. The Golden Gate mill was considered a model plant when it was built, but cyaniding methods have been so vastly improved during the past ten or twelve years that it would not now be considered modern had it been left in its original condition. New appliances have, however, been

installed from time to time, and the methods of operating have kept pace with the development of the art.

The fundamental principles of cyanidation have undergone no change since the MacArthur-Forrest process was first discovered. A dilute solution of cyanide dissolves the gold out of the ore, and then the gold is precipitated from the solution upon zinc. This zinc precipitate is then refined to bullion. These elementary steps are still included in all cyanide plants. Only one great improvement has been made in the process, and for that Mercur is also entitled to the credit. The vacuum filtration of slime was conceived in the Sunshine mill by George Moore, and was developed in the Mercur company's Golden Gate mill, at Mercur. This process has wonderfully broadened the scope of the cyanide process, and has been a large factor in the increased production of gold. Mercur, therefore, besides having put millions of dollars of its own gold in circulation, and helping to build up the State by furnishing employment for hundreds of men for the past twenty years, has also made a valuable contribution to the general welfare by introducing, developing and perfecting the cyanide process.

UTAH HYDROCARBONS.

The chief hydrocarbon field of the State is the Uinta Basin, in eastern Utah, with an area 170 miles long by 100 miles wide. This basin is bounded on the north by the Uinta range of mountains, on the south by the Books Cliffs, and on the east by the Danforth Hills and Yampa Plateau. The general elevation of the basin is five to six thousand feet. The whole of the formation of the Uinta basin is of sedimentary origin of the Eocene-Tertiary period. The hydro-carbons occur as true veins, that is, as fillings of fissures which cut through the sandstones of the region. These veins range from one to twenty feet in thickness, of solid gilsonite or Uintahite, as it is called. The depth to which these veins extend is not known as they have not been fully prospected and no workings have yet reached their lower

limit. At one point on the White river the vein is seen to be 3000 feet deep.

Much of the limited amount of work of extracting the black hydro-carbon material has been done by open cut methods of mining, as it was considered dangerous to use underground methods and employ the ordinary candles or lamps of the coal mines in the work. Of late years electricity has been brought to the mines, and now considerable exploiting is being done by regular underground methods, using the incandescent lamp for lighting. The vein substance is in most instances pure gilsonite with almost no pieces of wall rock or other impurity contaminating it. It has but to be loosened by picks, and shoveled into sacks, then taken to the surface ready for shipping.

This mineral brings a price of $40 to $45 per ton.

ABUNDANCE OF GRAPHITE.

A very superior quality of graphite is found at Perry, Utah, about five miles south of Brigham City, Boxelder county. Mr. Hoyt S. Gale, of the United States Geological Survey, recently made a careful examination of this deposit, and said that it is the best deposit of graphite in the United States.

This country produces but one-half of the graphite it consumes, hence the importance of this valuable discovery. A well developed ledge 27 feet wide and 4,000 feet long is in sight. Tests have proven an average of 90 per cent pure graphite, and running as high as 98 per cent. The development of this property and the manufacture of the product means much to the State, if the manufacture can be kept within the State. It is one of the industries that merits the support of home capital. Mr. A. S. Burrit of Salt Lake City, is president of the company owning the property.

GYPSUM.

Immense deposits of rock gypsum occur in Utah, in the following counties: Juab, San Pete, Sevier, Millard, Wayne,

Emery, Kane, Grand, Iron, and Washington. Those of Juab, San Pete, and Sevier are at present the ones being exploited.

The Nephi Plaster Company of Nephi, Utah, is operating on the Juab county deposits one mile east of Nephi. This gypsum bed is claimed to be the largest and purest natural deposit of gypsum ever discovered. The company has recently equipped its plant with the most modern machinery and is now producing the highest grade materials including finishing plaster, fibred and unfibred hardwall, casting and moulding plaster, dental plaster, and land and grain plaster.

The Robinson Plaster Company and the Jumbo Plaster Company, operating on the deposits of San Pete and Sevier counties, are putting out high-grade materials from their extensive beds.

The market for this plaster material extends northward to Vancouver and Victoria, through the Pacific States, and throughout the intermountain region.

Another gypsum field is found in Emery county along the west flank of the San Rafael swell. Some of the principal outcroppings are near the towns of Emery and Cleveland, in an area sixty miles long and twenty-five miles wide. Charles E. Lupton of the United States Geological Survey estimates the amount of gypsum contained in these deposits as 9,701,600,000 tons—2,424,400,000 tons in one bed, which has an average thickness of 10 feet, and 7,276,200,000 tons in another bed, which is 30 feet thick.

OIL FIELDS OF UTAH.

The fact that Utah has a number of oil fields has been sufficiently determined by development work in some and frequent occurrence of oil in others. Prospecting has been carried on intermittently in the past few years in San Juan, Grand, Emery, Uinta, Wayne, Juab, Washington and San Pete counties. Oil was produced in San Juan county in 1910-11, where a number of wells were drilled. One of these wells was pumped with a gasoline engine, using the crude oil for fuel as it somes from the well. This well was 600

feet deep and was believed to be capable of producing 250 barrels of petroleum per day. In February, 1911, the San Juan field had twenty-seven drilling rigs, only a portion of which were in active operation. The deepest well was reported 1,425 feet, which produced a high grade paraffin oil 38 to 40 degrees gravity. Oil and traces of oil were encountered in several wells at depths of 85, 600, 1170 and 1425 feet. The amount of oil produced was limited to the local consumption, which was small.

Oil has been known to exist in the San Juan field since 1882, when its presence was noticed by E. L. Goodridge The first drilling was done in 1907 and oil was encountered in 1908 at a depth of 225 feet. At this depth the well was reported as a "gusher," throwing oil to a height of 70 feet above the floor of the derrick.

A majority of the wells drilled were but prospect holes put down with the view of holding title to claims. Exploitation of the San Juan field has been confined principally to the Goodridge basin, which is reached by wagon road from Bluff, 25 miles to the east. The exploited portion of the field lies immediately north of the San Juan river. The nearest railroad point is Dolores, Colorado, on the Denver and Rio Grande system, a distance of 106 miles. Thompson, Utah, on the same railroad system, is 158 miles directly north, from which point there is a daily mail service to Bluff.

During the past two years, the Rock Island Railroad company has had a number of surveying corps in San Juan county with the evident intention of finding a suitable route for the extension of its line from Taos, New Mexico, through this and other southern Utah counties to some point on the Pacific coast. Pending railroad or pipe line means of transportation, there is but little activity in the San Juan oil field at the present time. During 1910, examination was made of the San Juan oil field by E. G. Woodruff, and a detailed description was published by him in Bulletin 471 of the United States Geological Survey (1912).

In a later report by David T. Day, of the same survey, it is stated that the San Juan river has cut à deep gorge across the field and exposed with remarkable clearness more than 1,400 feet of Paleozoic strata in a clearly horizontal position. Erosion has swept away the softer beds above the Paleozoic from the greater part of the field, but these beds are exposed in great escarpments on the north and east. More than 5,000 feet of strata, ranging from Carboniferous to Jurassic, inclusive, are exposed in the field. All of the oil is found in Paleozoic rocks in the Goodridge formation (Carboniferous), which is the lowest formation exposed in the canyon cut by the San Juan river. This formation consists of limestone, sandstone and sandy shale, which are exposed in the canyon in the western part of the field. The oil generally occurs in the sandstone, though traces have been found in the limestone in several wells. The formation contains nine beds of sandstone, all of which have been supposed by the prospectors in the field to contain enough oil to supply wells when they are drilled. All along the San Juan river, west from Goodridge to the boundary of the field, there are several oil springs. All these springs are near the level of the river, but not in the same strata, because they rise to the west and the river cuts into successively lower beds some of which are oil sands and give rise to oil springs.

The oils found are shown by analysis to be usually light in specific gravity. They yield more than the average amount of gasoline and of burning oil. The light specific gravity of the burning oil fraction compared to the average, the considerable amount of paraffin wax, and the comparatively low portion of unsaturated hydrocarbons show that these oils are somewhat similar to the oils of Lima, Ohio, with a smaller proportion of sulphur. In fact, the amount of sulphur is less than in many oils in Illinois, which are refined without special apparatus for eliminating sulphur. Taken altogether, these oils are well suited for the manufacture of gasoline and kerosene and there is every indication that the residuum would yield valuable lubricating oils.

The Virgin oil field in Washington county was a scene of considerable activity in 1907-08, when a number of wells were drilled with prospecting outfits. Californians led in the exploitation of this field. The discovery well was sunk in 1907 and oil was struck in July of that year at a depth of 566 feet below the surface. The well was deepened to 610 feet without increasing the quantity of oil. Oil was reported to have stood in this well to a height of 300 feet below the surface. A few hundred barrels of oil were pumped from the well. A flood, in the latter part of July of the same year, swept over that part of the field where the well was located and put a stop to further operations. A year later there were fifteen oil rigs in the Virgin field, but only four in operation. Seven wells had been sunk, supposedly to the oil horizon and some oil was struck in each, but the quantity has not been ascertained. No well was reported as good as the discovery well, which was stated to produce ten barrels of oil per day. A sample of the oil had a specific gravity of 0.9225, equivalent to 22 degrees Baume. It contained some paraffin and a large percentage of asphalt and considerable sulphur, including hydrogen sulphide.

No production is reported from this field in 1911-12. The nearest railroad point, on the San Pedro, Los Angeles and Salt Lake line is approximately 100 miles distant. Without means of transportation, there is no immediate prospect of any considerable activity in this field.

BUILDING STONES.

The term "building stones" as used in trade and commerce is of wide application, including all materials of structural utility, such as stone used for building purposes generally, and materials for fences, monuments, bridges, etc. It is by common usages in statistical reports intended to comprise clays, cement material and ornamental stones, exclusive of gems.

But few building stones in the world are utilized in their raw state for other than local application. Practically

every section of our own country produces its local supply. However, material of particular excellence may be and is utilized beyond its limits of occurrence.

Utah is rich in structural materials of superior quality, and in abundance to meet all demands.

Granite in a general sense comprises not only the rock of that name, as classified by the lithologist, but many allied species such as diorite, diabase, syenite, gneiss, and even dolerite and gabbro.

The widely known occurrences of granite rock in Little Cottonwood Canyon are of first importance. This rock is essentially a syenite, or more specifically a dioritoid granite. It has been designated as Temple Granite by the official geologists, in reference to the great Temple in Salt Lake City, which is constructed of this material. The rock constitutes the greater part of the colossal mountain mass, and its abundance is beyond computation or estimate.

Granite rocks of allied composition and similar quality occur in Beaver county and elsewhere to the south, while the gneiss of Farmington Canyon and the dioritoid rocks of Ogden Canyon and vicinity on the north are of great and growing importance.

Sandstones of special excellence occur in Salt Lake. Utah, and adjoining counties, and in smaller quantity in practically every county of the State. The bright colored sandstone of Red Butte Canyon, near Salt Lake City, and the gray Kyune sandstone from Spanish Fork Canyon, have been used in many of the most imposing buildings of the metropolis and other cities.

Limestone constitutes the main bulk of the Wasatch Mountains and other Utah ranges. The variety specifically known as Wasatch limestone is an excellent building material, and is used also as a flux in smelter processes. It is so rich in calcium carbonate as to be in demand for the production of carbonic acid gas in the sugar factories of the State. A variety of limestone occurring in San Pete county and elsewhere is oolitic—that is, composed of small globular

particles resembling fish eggs, hence its name—oolite. Some of the most pretentious residences in Utah cities are constructed of this beautiful stone.

Marble, really a crystalline variety of limestone, is found in Cache, Box Elder, Salt Lake, Utah, and southern counties.

Utah Onyx, also a calcium carbonate, but of such beauty as to preclude its use as a building stone proper, and to insure its popularity as a material for interior decoration, is found in great quantity. Box Elder, Salt Lake and Utah counties are the principal producers. The elegant wainscot in the corridors of the City and County Building, Salt Lake City, is of Utah onyx from the Pelican Point deposits on the shores of Utah Lake.

Concretionary Marble, otherwise known as nodular limestone, occurs in quantity incalculable at the head of Hobble Creek Canyon, near Springville, Utah county. This rock is of surpassing beauty as a building material, being made up of concentric nodules, from the size of a pea to that of a walnut, firmly cemented together. It takes a superb polish and is in demand as an ornamental stone.

Slate of excellent quality is quarried in Slate Canyon, near Provo City. It promises to displace the time-honored shingles, so common in the West, as a roofing material.

LIMESTONE.

The important market for limestone in connection with the smelting industry of Utah along with the market for the burned lime for building purposes, makes the immense formations of our mountains seem more than mere crust-making rocks of the earth. Throughout the state pure limestones are found in abundance for burning and for fluxing purposes.

VANADIUM, URANIUM, RADIUM, ETC.

These rare elements often occur together. The principal source of these minerals in the state is an extensive area in southeastern Utah. The vanadiferous minerals of Richard-

son, Utah, are the richest deposits of vanadium ores yet discovered in the United States. These are associated with carnotite, the scientifically interesting radio-active mineral from which the radium chloride, so much written of, is obtained.

PHOSPHATE ROCK.

The discovery of extensive phosphate deposits in the State has opened up a new and important industry in Utah. Although the home market for the raw or manufactured product of these deposits of fertilizer is limited, there seems to be no reason why, with the favorable rates of transportation which the railroads can give, the market may not extend rapidly in Honolulu, Japan, Australia, British Columbia, and the Pacific Coast states, as well as to the middle and eastern states.

The Phosphate series occurs within the Carboniferous rocks which outcrop over considerable areas in eastern, central and northern Utah. They consist of alternating layers of black or brown phosphatic material, shale and hard blue and gray fossiliferous limestone. While the series is about 90 to 120 feet thick, the beds of commercially valuable phosphate rock vary from three to twelve feet.

The main phosphate vein holds a thickness of five or six feet with remarkable uniformity over extensive areas. They have been prospected to some extent in Weber canyon, near Croyden, in the Wasatch mountains. The main development, however, has been made in the Crawford Mountains, in Rich county, about four miles east of the town of Randolph. Here three companies, the United States Phosphate company, American Agricultural and Chemical company, and the Union Phosphate company have been mining and shipping high-grade phosphate rock to the California markets for the past four years, making Utah first in production of phosphate rock of the Western States.

These phosphate deposits near Randolph extend north and south throughout the entire length of the Crawford

mountains, a distance of approximately twenty miles. Although Utah does not receive credit for having quite as great an area containing phosphate as is given to the States of Idaho and Wyoming, nevertheless, engineers familiar with the entire western phosphote field are of the opinion that nowhere else in the western deposits are there yet known physical conditions that will permit of as economical mining and development as are found in the Crawford Mountain range. A great portion of the Crawford range phosphates are still within the reserve created by the withdrawal of 1908.

This becomes of importance for Utah when taken in connection with the statements contained in "Fertilizer Resources of the United States," Senate Document No. 190, page 40. This document is a message from the President of the United States transmitting a report by the Bureau of Soils on the fertilizer resources of the United States.

THE MANUFACTURE OF FERTILIZERS AT SALT LAKE.

"The eastern shore of the Great Salt Lake is rapidly becoming a great railroad center, and is potentially one of the most important distributing points in the country. It is in close proximity to the largest high-grade deposits of rock phosphate in the world, and to the best deposits of alunite in this country. It is better situated than any other point to utilize any valuable deposits which the desert may yield. such, for instance, as nitrates. In the smelter fumes at Garfield and the other neighboring smelters it has at its door a vast source of material well suited to the production of sulphuric acid needed in the manufacture of superphosphate, a material (the smelter fumes) which, by the way, has become a great public nuisance, and must be disposed of in some way. All of the conditions point to Salt Lake City and Ogden as the great fertilizer manufacturing centers of the future. Hitherto the smelter interests have objected to converting their fumes into sulphuric acid on the twofold ground

that the people in their localities do not use fertilizers, and if they did use them, the production of acid would be far greater than the demand. It is doubtless true that attempts in this direction would at first lead to financial losses of magnitude. But there is good reason to believe that if the smelters of Utah were to follow the suggestion here offered they could put high-grade fertilizers on the market so cheaply that in a very few years the agricultural interests of the surrounding territory would use the entire output, and an important industry would be developed. Obviously, it would be a public work of the first national importance to develop such an industrial center midway in the territory between the Mississippi river and the Pacific coast."

The following papers relating to western phosphates and other mineral materials used as fertilizers have been published by the United States Geological Survey, or by members of its staff.

Blackwelder, Eliot, in Bulletin 430, pp. 536-551; 1910. Phosphate Deposits East of Ogden, Utah.

Gale, H. S., and Richards, R. W. Preliminary reports on the phosphate deposits in Southeastern Idaho and adjacent parts of Wyoming and Utah. In Bulletin 430, pp. 457-535; 1910.

Girty, G. H. Fauna of the Phosphate Beds of the Park City Formation of Idaho, Utah, and Wyoming. Bulletin 436; 1910.

Van Horn, F. B. The Phosphate Deposits of the United States. In Bulletin 394, pp. 157-171; 1909.

Weeks, F. B. Phosphate Deposits in the Western United States. Bulletin 340, pp. 441-447; 1908.

Weeks, F. B., and Ferrier, W. F. Phosphate Deposits in Western United States. In Bulletin 315, pp. 449-462; 1907.

ALUNITE AS A SOURCE OF POTASH SALTS.

A deposit of alunite recently discovered near Marysvale, Piute county, Utah, is being developed and may produce potassium sulphate on a commercial scale. The deposit is located near the head of Little Cottonwood canyon about 7 miles southwest of Marysvale, which is the present terminus of the San Pete & Sevier branch of the Denver & Rio Grande railroad. It occurs high in the Tushar Range, at an elevation of 9,900 to 11,000 feet above sea level, or about 4,000 feet above the railroad at Marysvale station.

The mineral alunite is a hydrous sulphate of potassium and aluminum with the symbol K^2O. $3Al^2O^3$. $4SO^3$. $6H^2O$. Theoretically it contains 11.4 per cent K^2O, 37 per cent Al^2O^3, 38.6 per cent SO^3, and 13 per cent water. The composition of the Marysvale mineral, according to the analyses that follows, is very close to the composition of the pure mineral given above.

ANALYSES OF ALUNITE FROM DEPOSIT NEAR MARYSVALE, UTAH.

	18 Per Cent.	19 Per Cent.	Dana. Per Cent.
Al_2O_3	37.18	34.10	37.0
Fe_2O_3	Trace	Trace	....
SO_3	38.34	36.54	38.6
P_2O_5	.58	.50	....
K_2O	10.46	9.71	11.4
Na_2O	.33	.56	....
H_2O+	12.90	13.08	13.0
H_2O-	.09	.11	....
SiO_2	.22	5.28	....
Total	100.10	100.18	100.0

No. 18 is a selected specimen of the supposedly best material. It consists of clear pink, subtransparent, coarsely granular, crystalline rock. No. 19 is a selected specimen of a light pink,.very fine granular rock, of almost pocelain like conchoidal fracture and no distinct structure.

As yet the developments on the Marysvale properties have shown only what is thought to represent a single large vein of alunite.

A conservative estimate of the tonnage in this deposit may be had by assuming an average width of 10 feet in the principal vein for a total length of 3,500 feet and neglecting the rest of the deposit as not sufficiently proved to be taken into consideration at present. This gives a surface area of substantially proved outcrop of 35,000 square feet, or more

* Bulletin U. S. Geol. Survey No. 511; 1912; 64 pages.

than four-fifths of an acre. The specific gravity of the Marysvale alunite has been determined in several specimens by W. T. Schaller, with results in close accord at about 2.82. Therefore a cubic foot of the ore may be assumed to weigh about 175 pounds. An acre of ground underlain by this rock to depth of only 1 foot would contain 3,800 short tons of alunite. If the area of available alunite is only 35,000 square feet, as stated above, there would be approximately 300,000 short tons of the rock for each 100 feet of depth so long as the deposit maintains its surface dimensions and quality. If the recoverable potassa or potash (as K^2O.) is estimated at 10 per cent of this total, such a deposit would yield 30,000 tons of potassa for each 100 feet in depth. This is approximately one-sixth to one-seventh of the total annual consumption of potash in the United States.

The Marysvale deposit, so far as known, is not of such magnitude as to afford a source of all the potash salts now consumed in the United States, but it may prove to be an important factor in providing an American supply that will perhaps be especially available to local and western markets, particularly in meeting the demand for higher grade salts. Possibly also the greatest importance of the commercial development of this deposit will be in the added stimulus it may afford to exploration for other similar deposits of this mineral, especially in this general region, and it is on the discovery of such other deposits that the provision of a home supply from this source must depend.

SULPHUR.

Native sulphur occurs in extensive deposits at Cove Creek, Millard county. The crude ore averages 20 per cent sulphur, although masses of pure sulphur are often encountered. The product from these mines is exceptionally free from arsenic and other deleterious substances. The beds are owned and operated by the Utah Sulphur Company, who have complete refining works at the mines. The production of recent years has been around 1000 tons per year. The

products of the refinery are crude sulphur, obtained by melting the sulphur from the rock by means of steam; powdered sulphur; sublimed flours of sulphur, and roll brimstone.

Other deposits of sulphur in Utah are found in the San Rafael canyon, located 18 to 20 miles west of Green river and about 5 miles from the mouth of the canyon of the San Rafael river. The canyon is about one-fourth of a mile wide where the deposits occur, and at least a dozen sulphur springs emitting hydrogen sulphide are present. The sulphur springs on the canyon issue from impure limestone debris which apparently overlies a thin bed of the same rock. Part of the sulphur is present in the form of small crystals, but a larger part is present in the form of small low, dirty color. The sulphur bearing strip is only 100 to 150 feet wide and about 750 feet long.

At present the market extends over the intermountain states, Arkansas, Texas and California. The material finds use in sheep dipping, tree spraying, fruit and hop bleaching, and sugar refining.

CEMENT.

Utah produces over one half million barrels of cement annually, valued at upwards of $650,000. Three concerns are now engaged in the manufacture of this important commercial material. The Utah Portland Cement Company, the office and plant of which are located in Salt Lake City, has done a flourishing business for several years. The rock from which it manufactures its cement is obtained in Parley's canyon, located a few miles from the works. The Union Portland Cement Company of Ogden is operating at 2,000 barrel plant near Croyden in Weber cayon, where it secures its calcium shale and limestone for a high-grade cement. The plans of both companies are modern and a good demand and market is found in Utah and surrounding States for the product. The Ogden Portland Cement Company, a newer concern, has established a plant at Baker's Spur, five and one-half miles northwest of Brigham City, and in the

manufacture of its cement makes use of a marl described by Ernest F. Burchard of the United States Geological Survey in the following article. (The two plants running on limestone and shale use the dry method and the marl plant uses the wet method of producing Portland cement):

"Limestones generally low in magnesium carbonate occur at many points in the Wasatch mountain area in Utah. Most of these rocks are of Carboniferous age. Many of them contain so much clayey matter as to fall below 75 per cent in lime carbonate, in which case they approach in composition the cement rock of the Lehigh district of Pennsylvania. In the Plateau district softer limestones of Tertiary age occur. In addition to the limestones just mentioned an interesting material has newly been discovered to be of value in the manufacture of Portland cement. It occurs in the form of marl underlain by clay. This deposit lies in the abandoned bed of a portion of the old Salt Lake Basin. It is a homogeneous, unstratified, grayish, fine-grained soft marl. At the surface the material is, in midsummer, fairly dry to the depth of one foot or more, but becomes damp below, and at the base salty water seeps in and fills holes where the underlying clay is excavated. The clay underlying the loam ranges from light gray through yellow to bluish in color, and is also fine grained. The deposit referred to lies 5.6 miles northwest of Brigham. The nearest remnant of Salt Lake is a small lake known as Boxelder Lake, a marshy tract which lies a short distance south of the marl deposit. The marl is four to ten feet deep, and the clay has been tested to a depth of eighteen feet. The marl runs generally between 1 and 3 per cent of magnesium oxide, between 40 and 46 per cent of calcium oxide, between 7 and 12 per cent silica and between 1 and 3.5 per cent of alumnia plus iron oxide. There has been found as high as 4.5 per cent sodium chloride (salt) in the marl, and the wet material carries as high as 32.29 per cent moisture. The clay carries 48 to 50 per cent silica, 16.5 to 18.6 per cent alumina plus iron oxide, about 7.6 per cent

of lime oxide, 2.5 to 2.8 per cent magnesium oxide, 2.7 to 2.9 per cent potassium oxide, 1.3 to 5 per cent sodium oxide, and about 2.25 per cent sodium chloride. In a wet condition the clay contains at much as 40 per cent of moisture."

FULLER'S EARTH.

The only deposit of Fuller's earth in Utah from which any considerable product has been obtained is located on the estate of William F. Young in Sanpete county. The tonnage has never been very heavy.

UTAH'S IRON WEALTH.

The Iron Springs district lies between longitudes 113 deg. 10 min and 113 deg. 26 min. 30 sec., and latitude 37 deg. 35 min. and 37 deg. 47 min. 30 sec., in Iron county, southern Utah, about 250 miles south of Salt Lake City and 550 miles from the harbor of San Pedro, Cal., on the Pacific Ocean. The San Pedro, Los Angeles and Salt Lake Railroad runs within 22 miles of the district on the west, Lund being the nearest station. The district can also be reached by way of a spur of the Denver & Rio Grande Railroad running down to Marysvale, 80 miles northeast of the district, thence on by stage.

The elevation ranges from 5,300 to 8,000 feet.

The drainage is through small creeks leaving the mountains and hills and soon losing themselves in the desert.

The tops of the Harmony mountains retain snow until the middle of summer, and consequently have an abundance of vegetation, such as yellow pine, fir, cottonwood, quaking aspen and mountain mahogany. The tops and slopes of the other mountains are dry and are covered with a growth of scrub cedar and pinon. Shrubs, sagebrush, and several species of cacti are also abundant, but grasses are lacking. The surrounding desert presents the variety of sagebrush, rabbit brush, greasewood, and shad scale characteristic of the desert elsewhere in the Great Basin.

Description of the Iron Ores.

The iron ores occur in disconnected masses within a general area about 1½ miles wide by 20 miles long, running northeast and southwest. They lie for the most part on eastern and southern slopes or foothills of The Three Peaks, Granite mountain and Iron mountain, between elevations of 5,600 and 6,700 feet, but some of them, as on Iron mountain, appear at or near the tops of the mountains at elevations between 7,000 and 8,000 feet.

Some of the iron-ore exposures stand out as much as 200 feet above the surrounding country as black, jagged ridges. Others, including several of the larger deposits on the lower slopes, do not stand above the surrounding rocks, but are known by isolated exposures and black iron-formation fragments disseminated in the loose detrital material at the surface. Some of the ore does not appear at the surface at all, being covered by andesite detritus washed from the upper slopes, though, even here, fragments of ore are likely to appear in the detritus farther down the slopes. In such places the exact shape and distribution of the deposits cannot be determined without trenching or pitting. Fortunately such work will suffice fairly well throughout the possible ore-bearing areas, though there are places where areal extensions of iron-ore belts may be found by underground exploration, or where belts mapped as continuous on the basis of the surface fragments may really be discontinuous. The deepest pits in the district, 130 feet, have not yet reached water level.

During the years 1874 to 1876 a small furnace, with a daily capacity of five tons, was built and operated at Iron City, five miles southwest of Iron mountain. The product was taken to the then prosperous silver mining camp at Pioche, Nev., and to Salt Lake, Utah. Later the old stack was torn down and a new one, projected to take its place, never rose higher than the foundation. The coal was derived from the Harmony mountains, five miles to the southeast. The ore used in this furnace was taken out of the Duncan

claim, one of the southernmost exposures of ore in the Pinto groups of claims, from shallow pits and short tunnels near the surface.

From time to time since the discovery of the deposits, pits and tunnels have been sunk in the ore, principally to meet assessment requirements, but partly to show up the ore bodies. Some of the more vigorous exploration was conducted during the years 1902 and 1903. The total number of pits sunk to date has been approximately 1,600, of which 30 have gone to a depth greater than 50 feet. The maximum depth has been 130 feet.

Kinds and Grades of Ore.

The following description applies to the ores as they appear above water level. Pits have not yet been sunk below this depth.

The ore is mainly magnetite and hematite, usually intimately intermixed, but locally segregated. So far as present information goes (and it does not go far below the surface) the magnetite constitutes about 70 per cent and the hematite 30 per cent of the whole. As hematite appears more abundantly below the surface, it is thought likely that deeper exploration will develop a higher percentage of hematite. At the surface the ore is ordinarily hard crystalline magnetite and hematite in porous, gnarled and contorted masses, with coarsely crystallized quartz and fibrous chalcedony as the principal gangue mineral, filling, wholly or partly, cavities in the ore. Other gangue minerals occurring in small and practically negligible amounts are apatite, mica, siderite, diopside, garnet, pyrite, chlorite, calcite, barite, galena, amphibole, copper carbonates, limonite, and amethyst. Of these minerals barite and galena are more closely associated with the limestone than with the ore. Melanterite, associated with pyrite, was found in process of formation in the long tunnel on the Duncan claim. Beneath the surface the ore is usually softer and contains a larger proportion of soft, bluish, reddish, brownish, grayish and greenish banded

hematite, limonite, and magnetite in greatly varying proportions and relations. The gangue materials are more abundant than near the surface, and calcite is in relatively increased proportion as compared with the quartz. The banding in the contact ores partly represents the bedding of the limestone, which, as will be shown later, the ore replaces. Banding in the dike or vein ores in the andesite is of unknown origin, possibly the result of original deposition. Some of the softer ore at lower levels entirely lacks this banding. Locally, as on the west side of Lindsay Hill, the contact ore contains parallel streaks of a yellow clayey-looking material. On examination this resolves itself into a mixture of iron carbonate, iron sulphate, and glass, and probably some residual clay. Some of the narrow ore veins in the andesite possess a comb structure formed by the meeting and interlocking of apatite crystals projected from the walls sometimes not entirely closing the vein.

In the ore breccias the cements are magnetite, limonite, calcite and quartz. At the Milner mine and elsewhere the magnetite has been deposited first about the fragments, here consisting of quartzite, then hematite, then limonite, but exceptionally in the same locality the reverse order appears.

The texture of the ore as a whole is good for furnace use. The harder ores will need crushing.

	Iron Springs Ores.	Lake Superior Ores.	Alabama Hematites.
Iron (metallic)	56	59.6	37
Silica	7	7.5	13.44
Phosphorus	.300	.067	.37
Lime and Magnesia	4	1.3	16.2
Alumina	1	1.5	3.18
Water, above 220 deg	3	4.0	.50
Copper	.027	.....	.....
Sulphur	.057	.019	.07
Manganese	.196	.....	.....
Carbonic Acid	.....	.....	12.24

It will be noted that the Iron Springs ores are intermediate in composition between the two other great classes of ores.

Size and Quantity of Ore Deposits.

The iron-ore deposits vary from mere stringers to those having an area of 1,670,000 square feet. The aggregate surface of all the ore deposits of the district is 5,430,000 square feet or 0.2 square miles.

The aggregate tonnage of all grades of ore in the district, determined by multiplying the known area by the best available information as to depth in pits, drill holes, and erosion sections, is 40,000,000 tons. The largest single deposit, figured on the same basis, has 15,600,000 tons. It is altogether likely that the figures are much too small rather than too large, because the depths used in the calculation have been those actually observed, and observation has not yet gone to the bottom.

UTAH'S STEADY ADVANCE.

Utah's prominence as a mining state has been gained gradually as a result of the extensive development of enormous medium and low grade deposits. There have been no spasmodic and temporary gains in her metallic output, neither have there been serious losses, as the years of prosperity or adversity in mining arrived. No decline in lead and silver or slump in copper has caused collapse. Her advance has been rapid but regular. The prospects are brighter now for increased output in future years than they ever were before.

The dividends from her mines and smelters indicate the substantial nature of these industries. For 1907 the reported dividends amounted to more than $5,000,000, and this was no exception, as the bread money distributed for a number of years has hovered around this flattering figure.

SECURITY OF INVESTMENTS IN UTAH.

There have been fewer labor troubles in Utah than in any mining State in the West. Seldom have the mining and metallurgical operations in the State been interfered with by conflicts between capital and labor. The sentiment of the people of Utah is against strikes and lockouts. Laborers have never demanded exorbitant wages. Mine and smelter managers have acceded to the request for increased pay during especially prosperous years, and the workmen have allowed this increase to be taken off at times of depression. Capitalists are now appreciating this favorable relation between capital and labor in Utah, and are showing a preference for our State as a place to invest their money.

NONMETALLIC MINERALS.

Salt.

There are billions of tons of salt in the waters of Great Salt Lake, and extensive deposits of rock salt in the mountains of the State. From these sources the State is producing yearly about thirty-five thousand tons. With the steadily increasing facilities for transportation throughout the State, this output can be readily be increased, in the near future, many fold.

The Inland Crystal Salt Company, of Salt Lake City, is harvesting almost the entire salt output of the State from the waters of the Great Salt Lake. Their works are located near the famous Saltair resort. The water of the lake is pumped by centrifugal pumps into shallow pounds, where solar evaporation in the dry summer months carries off the water, leaving the crystal salt behind. The evaporating season lasts about one hundred days, during which time there is constant pumping of the brine into the pounds, the aim being to keep the evaporated solution from becoming so concentrated as to deposit other solid matter with the crystals of sodium chloride. When the season is over the mother liquor is flushed out of the pounds, leaving a layer of soft

crystals from three to six inches deep, covering the entire area of the shallow pounds. The average crop is four and one-half inches thick, amounting to 700 tons of salt per acre. Each pound has been previously lined with a thin deposit of salt by this same process, and the salt lining has become very densely caked, so as to form a firm bottom to the regular salt crop.

Thus the crop can be readily shoveled up into windrows and from here into cars and barrels, and then dumped into piles of about one thousand tons each. These piles soon become covered with a very hard crust. The outer layer partly dissolves with the rains, and the crystals become cemented together very firmly around the outside of the pile. These piles may be left with safety for years, if need be.

Much of this crude salt found a market in the past for chloridizing, roasting and leaching of ores. At present there is little call for salt for these purposes, but with the advance of metallurgical experimentation on wet methods, there seems to be promise of a revival of wet methods, wherein much sodium chloride will be required.

For table use the salt is refined at the works. The process consists of crushing, drying and winnowing while hot. The efficiency of the fans in separating the efflorescent sulphates from the crude salt is abundantly demonstrated by a comparison of the analyses of crude and refined products. The refined salt is ground and sifted to give products of the proper degree of fineness, as required for packing, table and dairy use. The salt so prepared is of exceptional purity, as the following analysis shows:

Sodium chloride (pure salt)	99.927
Calcium Sulphate	.058
Insoluble matter	.007
Moisture	.008
Calcium	Trace
Magnesium	Trace
	100.00

The dense brine of the Great Salt Lake constitutes a vast mine of chemical riches, offering a vast variety of chemical products other than salt at the minimum cost of preparation. The total solid matter in solution in this water amounts to about 18 per cent, or more than five times that of sea water. The solid consists principally of sodium and magnesium salts. The chlorides and sulphates predominate.

Next to salt, sodium sulphate claims attention. This mineral, known as marabilite, crystallizes from the lake water in the winter, when the temperature reaches 20 to 30 degrees Fahrenheit. Hundreds of thousands of tons of this material are deposited in the lake bottom and are washed upon the shore whenever the temperature reaches the low point given. This sulphate is of importance in the manufacture of soda.

There has recently been explored a most important salt deposit in the form of an immense salt bed in the Great American desert, about 110 miles west of Salt Lake City, and 15 miles east of the Utah-Nevada State line. The track of the Western Pacific Railroad runs directly through these beds. This salt covers an area of 60 square miles. The deposit varies in depth from six inches to seven feet or more, in places where telegraph poles were set. It is almostly perfectly white and absolutely free from dirt, rubbish or growth of any nature. Providing the deposit only averages one foot thick, the amount of salt to the square mile will amount to more than one million tons, or sixty millions of tons in the whole deposit.

The United States Congress, by the provisions of the Enabling Act for Utah, intended to give to the University of Utah all the saline lands of the State. Notwithstanding this fact, prospectors staked out their claims over the deposit and contested their rights in the courts. The Supreme Court of Utah rendered a decision in favor of the State University. The case was carried to the United States Supreme Court, which decided adversely to the State, that court failing to allow the State the benefit of the language contained in

the Enabling Act by which it was intended that all the saline lands in the State should be given to the University.

A considerable amount of salt is annually mined from the beds of rock salt in Sevier county, near Richfield and Salina.

Utah's production of salt for the year 1911 was approximately 275,000 barrels, valued at $173,000.

TIMBER

Forest Nursery Site, Salt Lake County, Utah.

TIMBER RESOURCES.

The development of the agricultural, livestock, mineral, water power and the various industries dependent upon those natural resources, has been so profitable and the growth so rapid within the State of Utah that but little attention has been given to commercializing the timber resources of our mountains, or to the upbuilding of trades relating to these resources.

The cities, towns and communities that draw upon the mountain streams for domestic use, the power plant operator and farmer whose very existence depends upon the stream flow from the canyons, give small attention to the use or maintenance of the forest cover, which is so great a factor in the regulation and distribution of the water supply of the State.

It has been proved beyond question that the condition and quality of the forest cover makes for the good or evil of the water user; when trees, shrubs and plant life are thick and flourish along the mountain sides rainfall and snow will be held back and allowed to sink into the earth, filling up the many underground crevices and reservoirs which store the moisture, and by gradual output into streams distribute the water supply over a period of several months. On the other hand, if the forest cover has been burned off or destroyed by the continuous over-grazing of live-stock, and is left in comparatively bare condition, the winter snows will melt rapidly upon the first approach of spring, the rains will pour off the mountain slopes, and the creeks and streams will become raging torrents, sweeping everything in their path, causing great damage to farm and community property, with the result that when the dry summer months come and water is needed for agricultural and other purposes, the streams will have no reserve to supply them and water users of every kind lose money and curse the bad luck of a so-called "dry year."

Many of the most important watersheds in the State were in deplorable and bare condition when the Federal government in 1906 began active work of supervision and care of the State's forests and other resources through the Forest Service branch of the Department of Agriculture. Twelve national forests, or forest reserves, embracing a total of 7,436,000 acres, are established in the State; their importance of location and relative extent can be seen on the resource map of Utah.

The Forest Service in its short administration of the State's timbered areas and watersheds has obtained many beneficial results, not only for the grazing and stock-raising industry, but to water users in general.

There now exist no uncertainty of rights nor war between sheep and cattle men, no one range is overcrowded, and wasted drainage areas are now in improved condition, as to plant life cover in comparison with what existed six years ago.

The Forest Service is making energetic and intelligent headway in dealing with problems peculiar to the various watersheds of the State. An instance of the highly scientific and practical work which has been in progress during the year 1912 is found in the establishment and operation of the Utah Grazing Experiment Station, situated on the Manti National Forest in San Pete county.

The primary purpose of this station is to determine the relation of sheep and cattle grazing to erosion and average stream flow. The definite results which will obtain from this work will be of great and lasting benefit, particularly to the Great Salt Lake Basin region. And the future settlement and development of the unoccupied agricultural lands adjacent to the National forests and dependent upon the drainage area covered thereby, is so intimately and vitally related to the sustained maximum stream flow during the annual irrigation period that nothing can be of more importance to the State in general than accurate information on these subjects.

In addition to these important determinations the grazing experiment station is making a study of the effect of grazing upon the reproduction of forest trees, determinations of the relative value of the different forage plants, the re-vegetation of over-grazed ranges and other important factors looking to the proper utilization of the forage resources of the National forests.

The primary function of the men in charge of the work at the experiment station will be to restore ground cover, thereby increasing the storage efficiency of capacity of the watersheds of the principal streams, by determining the best methods of regulating the use of the ranges and by re-vegetating depleted areas with foreign and native forage plants which most readily adapt themselves to the soil and climatic conditions encountered in the mountain ranges of Utah.

The final outcome of this work will not result in the exclusion of livestock from the drainage areas, since full efficiency and complete utilization of the forage crop is desired by the Forest Service; but, on the other hand, fuller use will be accorded to all as the ranges are gradually restored to normal conditions and practical methods of handling stock on the National forest areas are adopted by the stock men.

Other advantages and improvements are obtained by the work of the Forest Service, such as the building of roads, trails, bridges and telephone lines, and for the furtherance of these undertakings Congress, under date of August 10, 1912, authorized the expenditure by the Department of Agriculture of the sum of $13,524 for the construction and repair of wagon roads within the State. This sum will be expended within the following National forests:

Cache, Uinta, Fishlake, Powell and Dixie, contemplating the total construction and repair of sixty-nine miles of road, to be completed during the summer of 1913.

TIMBER RESOURCES AND OPPORTUNITY.

With the extensive information regarding the timbered areas of Utah which has been obtained and compiled by the Forest Service, there are, indeed, great opportunities afforded in this State for the establishment and successful operation of logging and milling enterprises on large scales. Most of the available timber of the State lies within the National forest boundaries, and is subject to purchase under terms and conditions specified by the Secretary of Agriculture. These terms are reasonable to the investor, and the conditions are only such as to prevent needless waste and destruction of the forest tracts. Upon application, timber desired is advertised for thirty days, at the end of which time the sale is awarded to the highest bona fide bidder. Detailed information relating to any particular tract of timber can be had upon application to the District Forester, Forest Service, Ogden, Utah.

It has been due to the lack of reliable information on the timber resources of Utah that this important industry has so long been held back. Now, however, large timber land areas have been estimated and mapped by expert government cruisers, especially the more extensive areas where the timber is accessible and offers excellent facilities for operations on a large scale.

The annual lumber consumption of the northern part of the State is placed at about 150 million feet, this demand at present being supplied almost entirely by large mills on the coast, which ship the manufactured lumber into Utah by rail. The few small portable mills operating locally supply only about 12 million feet; it is thus seen that a large local mill would have practically a virgin field of operation.

The native merchantable saw timber in the State is Western Yellow Pine, Engelman Spruce, Lodgepole Pine, Douglas Fir and White Fir, while the cordwood species are Juniper, Pinyon Pine and Quaking Aspen.

It is estimated that on the National forests of the State there are between seven and eight billion feet of merchant-

Pine Forest Damaged by Fire.

able saw timber, railroad ties and timber suitable for mining purposes.

LOCATION OF THE MORE IMPORTANT TIMBERED AREAS.

The heaviest bodies of timber lie in three portions of the State.

On the Uinta mountains (see Resource map) in the northern portion there is estimated to be approximately three billion feet of timber. At the head of Provo river there is a tract of 100 million feet of Engelman Spruce and Lodgepole Pine, easily accessible for logging purposes, and which can be driven down the Provo river to the D. & R. G. railroad tracks with little difficulty. This excellent tract averages 10 thousand feet board measure per acre. The logging problems involved are not difficult, and the outlay necessary to construct logging roads and chutes will not be great. The river has already been driven on a small scale and a drive of 50 miles would land logs at Heber City on the railroad, where an excellent site for a large mill could be obtained. In addition to the saw timber, this tract will furnish large amounts of railroad ties and mining timber, for which there is always a good local market. By reference to the Resource map the accessibility of this tract is seen at a glance, and a mill located at some convenient railroad point on the Provo river would be situated centrally as regards the large markets of Northern Utah and Southern Idaho.

Here is, indeed, an excellent opportunity hitherto overlooked, now knocking at the door of the enterprising lumber man and investor.

On the northern slopes of the Uinta forest there is another extensive tract of timber covering the headwaters of Black's Fork and Smith's Fork—contributaries of Green river. Both of these streams can be driven to railroad points at small expense, the timber involved being estimated at 150

million feet of saw material, ties and mining timbers, the stand averaging 8 thousand to 10 thousand feet board measure per acre.

In the southern part of the State, the watershed of the Sevier river embraces an immense amount of excellent timber. A cruise of this area just completed the past summer by the Forest Service shows between two hundred and fifty million and three hundred million feet of accessible timber which can be exploited by a short railroad extension from Marysvale. This timber is 65% Yellow Pine, 25% Douglas Fir, 40 inches. It is rolling country, and the cost of logging will therefore not be unreasonable. The outlay necessary to exploit this timber will be considerably more than in the other cases mentioned. In fixing stumpage and the contract period, however, the government takes into consideration the time and outlay involved on the part of the operator in constructing necessary improvements to carry out his operations.

The timber resources of the Kaibab National forest, which forms the north bank of the Grand Canyon of the Colorado river in northern Arizona, must be exploited by the construction of a railroad through southern Utah, and this timber will therefore enter into the markets of the State. The Kaibab forest, famous for its picturesque scenery and visited by hundreds of tourists each year, contains one billion feet of Western Yellow Pine and five hundred million feet of Douglas Fir and Engelman Spruce saw timber, practically all of which is easy to log and which can be placed on the markets when a railroad enters the southern Utah territory. The Kaibab plateau, as its name indicates, is a high rolling plateau which makes the logging problems involved comparatively simple, since logging railroads can be constructed throughout the timber. This is a solid belt of forest covering over four hundred thousand acres broken only by grassy parks. The stand varies from 4,000 to 20,000 feet board measure per acre. The average diameter of the Yellow Pine is about 25 inches; many trees, however, run-

Depleted Forest Cover. Result of Burning and Sheep Grazing. A Slope that Can Be Planted.

ning as high as 50 and 60 inches on the stump. The Engelman Spruce and Douglas Fir will average 20 inches on the stump. The extension of the railroad into this country will develop in addition to the timber resources a large agricultural and stock-raising region and an extensive tourist trade to the Grand Canyon of the Colorado, which offers the most magnificent scenery in America.

On the Uinta, Manti, and Fishlake National forests there are vast areas of Quaking Aspen, running from five to thirty cords per acre. An estimate made on the Uinta forest the past summer shows two million two hundred and twenty thousand cords of Aspen, averaging nine cords to the acre. On White river there are two hundred thousand cords accessible to the railroad, and this area offers an excellent opportunity for a large pulp mill. The Fishlake and Manti forests contain even more Aspen than is on the Uinta and offers similar attractive opportunities for pulp mills. Detailed information, including estimates and maps covering the different timber sale opportunities and the terms under which the timber is sold from the National forests can always be obtained from the District Forester, Forest Service, Ogden, Utah.

FORESTS AND TIMBER.

About 94% of the timbered areas of Utah are embraced within our National forests and the estimated stand of timber therein is 7,754,800 M. board feet of saw timber and 10,432,240 cords of Juniper, Aspen and Pinyon Pine, the total valuation of the saw timber and cordwood being placed at $18,117,660.00. The stand and valuation of the timber by forests is shown in the following table:

ESTIMATED STAND AND VALUE OF TIMBER IN THE NATIONAL FORESTS OF UTAH.

Forests	M. B. F. Saw Timber	Cords Cordwood	Value*
Ashley	2,220,000	528,000	$ 4,572,000.00
†Cache	72,000	17,240	148,310.00
Dixie	76,000	1,070,000	419,500.00
Fillmore	340,000	755,000	868,750.00
Fish Lake	240,000	1,826,000	936,500.00
La Sal	208,000	800,000	617,000.00
Manti	186,300	502,000	498,100.00
Nebo	54,000	304,000	184,000.00
Powell	1,750,000	1,200,000	3,800,000.00
Sevier	755,000	740,000	1,695,000.00
Uinta	1,834,000	2,260,000	4,233,000.00
Wasatch	19,000	430,000	145,500.00
Total	7,754,800	10,432,240	$18,117,660.00

*Saw timber is valued at $2.00 per M. and cordwood at 25c per cord.

†276,640 of the 538,840 acres comprising the Cache forest are located in Idaho.

Government Telephone Lines, Trails, Wagon Roads, Bridges, Drift Fences, Stock Separating Corrals, and Water Development Projects for Stock Watering Purposes on the National Forests in Utah, Constructed and in Operation June 30, 1912.

Forests	Telephone Lines	Roads	Bridges	Trails	Drift Fences	Corrals	Water Development
	Miles	Miles	Number	Miles	Miles	Number	Number
Ashley	60.62	25.00	..	135.00	.....	2	2
Cache	49.43	1.00	7	79.30	.....	1	24
Dixie	2.57	60.00	..	29.70	5.25	3	5
Fillmore	.10	60.50	..	92.50	.....	1	2
Fish Lake	120.00	12.00	1	.25	.....	..	8
La Sal	32.00	7.00	..	20.00	3.75	4	..
Manti	36.00	26.50	3	7.00	6.00	1	3
Nebo	.....	16.00	..	46.75	11.00	..	23
Powell	125.00	.....	..	.....	1.75	..	..
Sevier	99.00	8.00	..	2.00	.....	5	2
Uinta	24.00	70.25	5	220.00	.....	1	2
Wasatch	14.50	.40	3	22.00	.....	..	4
Total	563.22	286.65	19	654.50	27.75	18	75

Number of Cattle, Horses, Sheep and Goats Grazed on the National Forests in Utah for the Years 1910, 1911 and 1912.

Forest	Cattle and Horses			Sheep and Goats		
	1910	1911	1912	1910	1911	1912
Ashley	2,969	3,773	5,195	78,031	93,511	94.006
Cache	11,710	10,631	12,755	92,517	84,752	114,791
Dixie	11,052	12,608	12,687	3,600	3,000	600
Fillmore	14,049	13,759	13,917	47,137	45,014	42,766
Fish Lake	12,789	12,300	14,028	55,756	52,675	56,158
La Sal	15,585	16,473	17,663	53,691	50,865	40,262
Manti	18,375	18,615	17,036	183,384	181,099	158,508
Nebo	15,033	15,124	15,546	5,000	5,000	5,000
Powell	9,643	11,703	11,649	66,700	75,230	73,200
Sevier	10,588	10,300	10,433	118,534	120,270	133,035
Uinta	14,227	15,869	18,523	272,476	260,236	259,087
Wasatch	9,388	9,570	8,793	15,586	15,576	14,296
Totals	145,408	150,725	158,225	992,412	987,228	991,709

Timber Cut on the National Forests in Utah for the Fiscal Years 1910 and 1911.

Forests	Quantity		Value	
Ashley	1,252.69	1,698	$ 2,407.03	$ 3,293.86
Cache	876.80	1,192	1,965.71	3,110.79
Dixie	165.68	193	302.87	352.05
Fillmore	535.29	1,139	1,427.07	2,614.51
Fish Lake	639.66	704	1,850.38	1,950.80
La Sal	101.52	1,043	448.98	2,523.25
Manti	3,075.65	4,087	7,693.97	11,129.50
Nebo	5.00	9	14.69	19.29
Powell	402.33	581	757.37	1,157.64
Sevier	517.00	442	1,407.13	1,079.52
Uinta	2,342.99	2,308	3,846.12	4,374.63
Wasatch	306.63	264	473.44	355.69
Totals	10,311.24	13,660	$22,594.76	$31,961.53

Timber Cut on the National Forests in Utah for the Fiscal Year 1912.

Forests	Quantity	Value
Ashley	1,717	$ 3,607.23
Cache	676	1,728.82
Dixie	127	312.81
Fillmore	750	1,829.54
Fish Lake	1,002	2,550.67
La Sal	823	2,318.09
Manti	3,709	9,681.02
Nebo	15	39.00
Powell	788	1,519.53
Sevier	743	1,800.66
Uinta	1,202	2,462.88
Wasatch	62	101.10
Totals	11,614	$27,951.35

Alienated Lands Within National Forest Boundaries in Utah. June 30, 1912.

Forests	Gross Area.	Alienated	Net Area
	Acres	Acres	Acres
Ashley	992,100.00	8,137.02	983,962.98
Cache	309,738.00	47,861.36	261,876.64
Dixie	460,800.00	20,581.51	440,218.49
Fillmore	578,500.00	37,335.34	511,164.66
Fish Lake	668,590.00	59,832.14	608,757.86
La Sal	440,000.00	18,410.30	421,589.70
Manti	784,000.00	65,496.88	718,503.12
Minidoka	92,280.00	21,053.10	71,226.81
Nebo	281,400.00	6,398.80	275,001.20
Pocatello	10,815.00	3,531.54	7,283.46
Powell	704,700.00	8,496.31	696,203.69
Sevier	802,660.00	97,227.79	735,432.21
Uinta	1,286,500.00	69,349.32	1,217,150.68
Wasatch	309,000.00	23,329.04	285,670.96
Totals	7,721,083.00	517,040.54	7,234,042.46

Timber Sales on the National Forests in Utah in the Fiscal Years 1910 and 1911.

Forests	No. of Sales		Quantity Sold		Value of Sales	
	1910	1911	1910	1911	1910	1911
Ashley	22	36	1,111.85	2,619	$ 1,986.37	$ 5,227.50
Cache	41	87	900.70	1,476	1,827.32	3,902.70
Dixie	13	9	202.00	122	324.10	221.00
Fillmore	22	29	288.76	832	532.33	1,783.75
Fish Lake	13	17	329.00	1,681	984.50	4,429.60
La Sal	13	17	268.50	5,060	567.45	14,320.00
Manti	59	89	5,904.88	2,715	17,923.90	8,130.14
Nebo	3	4	14.00	13	38.00	27.50
Powell	13	29	343.00	663	670.00	1,299.50
Sevier	11	17	523.00	405	1,295.00	1,011.75
Uinta	40	45	5,342.55	898	9,236.83	1,687.09
Wasatch	22	23	249.60	281	382.10	378.25
Totals	272	402	15,477.84	16,765	$35,767.90	$42,418.78

Timber Sales on the National Forests in Utah in the Fiscal Year 1912.

Forests	No. of Sales	Quantity Sold	Value of Sales
Ashley	25	945	$ 2,034.36
Cache	61	658	1,790.46
Dixie	13	232	535.25
Fillmore	43	588	1,353.92
Fish Lake	16	2,332	5,843.38
La Sal	17	760	1,960.00
Manti	110	1,637	2,940.06
Nebo	2	11	31.50
Powell	31	802	1,584.00
Sevier	35	735	1,784.25
Uinta	38	4,848	11,803.09
Wasatch	17	99	172.35
Totals	408	13,647	$31,832.62

FISH and GAME

Fish Hatchery No. 1, Murray, Utah.

FISH AND GAME IN UTAH.

The Conservation Commission feels that in the fish and game industry there is a special field for its activity. In the past it has received but little if any consideration, for the reason that but little was known as to its benefits or profits.

The State has invested now in its water rights, and at its various hatcheries some $66,800.00. Recently, a large number of private fish industries have been started, and it is a matter of comment that in most instances these industries are revenue producers. There are four "hatcheries" now operated under the direction of the State. Hatchery No. 1, at Murray, has an equipment valued at $33,000, and has a capacity of 2,000,000. More than seven million fish eggs have been produced here during the past two years. Here about 18,000 stock fish are maintained and from this point streams in the northern part of the State are stocked.

Hatchery No. 2, at Springville, also has a 2,000,000 capacity and equipment valued at $23,500.00. Some 10,000 stock fish are now to be found here. Trout fry from this plant are distributed in Utah and in streams in the central part of the State.

Hatchery No. 3, at Panguitch, has a building, one million capacity, and an equipment valued at $6,500.00.

Hatchery No. 4, at Fish Lake, has a building of one million capacity and an equipment valued at $3,300.00.

The Fish and Game Department of the State has made wonderful progress during recent years, and is now assuming proportions that will, in the near future, make it one of the greatest revenue producers of the State, not only for its own maintenance, but as a commercial industry for the people.

ABUNDANCE AND VALUE OF FISH.

The abundance and value of fish in Utah can hardly be over-estimated. More than 30,000 of our citizens engage in the industry, either for sport or as a means of livelihood. Each year, from nine to eleven millions of game fish are "planted,"

but unfortunately, this work suffers a handicap, since many of our mountain streams are diverted entirely for irrigation uses. Through not being properly screened, hundreds of thousands of fish hatched and planted every year by the State are carried out upon fields and destroyed. The enactment of a law requiring irrigation companies to install suitable screens to prevent the further destruction of fish is commended to the Legislature by this Commission.

Our State abounds with pure water. The rivers and lakes are the most desirable for fish culture. In passing, we cannot help mentioning Utah Lake, situated in Utah county. From the fish-interest standpoint this grand body of water has nothing superior in any of our inland states. It is full of the choicest of fish foods, and will, in the near future, produce the major portion of our game fish. This year, by the protection given the bass, not less than 10,000,000 were hatched in this lake. It is very noticeable in Cache, Box Elder, Weber and Utah counties, where bass are on the increase, that the carp are on the decrease.

It is the desire of the Fish and Game Department, when the streams and lakes are properly stocked and hatcheries sufficient to keep up the supply, which should be in the next three or four years, to have an open season the year round for fishing for all kinds of game fish.

WILD GAME BIRDS.

The law passed by our last Legislature, closing the season for four years for the hunting of game birds, will materially increase them in our State, and with the importing of the Hungarian pheasant and other birds by the department this season, should presently make Utah a paradise for hunters in the open season.

Some one has defined ornithology to be the study of birds from the standpoint of dollars and cents; and it matters not whether the birds be classed as a game bird, a song bird, or an insectiverous bird, its value living far exceeds its value dead. Think of what this means to the State, and to you.

Consider the worth of fish and fishing or hunting—the pleasure, experience, recreation, with consequent better health and improved ability to meet all demands made. And in addition think of the cash value of the many tons of fish and game taken.

Our laws must, as nearly as possible, be drawn to meet the necessities of the entire State. The uniformity, as near as possible, of the State laws throughout this intermountain country would be a most excellent thing. Some amendments to our present laws will be necessary, and probably will be made at the next session of the Legislature.

The all-important thing to do in our State is to give full protection to all fish and game interests as far as it is possible. And with the aid we are receiving from the people of the State at this time we are sure of success.

Utah as a Place of Residence

By B. B. Mann.

There are many reasons why the average American citizen, looking for favorable natural conditions, should select Utah as a place of residence. In the first place, Utah has more sunshine through the year than is found at Boston, or at Chicago, or at Cincinnati, or at Memphis. And sunshine has a good deal to do with making life pleasant. In summer the heat is less intense at Salt Lake City than at Springfield, Illinois; or at Cincinnati, or at Memphis. In winter the cold is less severe at the Utah capital than at the Tennessee metropolis. The annual mean temperature at Salt Lake City is 51.8 degrees above zero. It is 49 at Provo, and 59 at St. George, in the extreme south of the State. Taking the year together, Cincinnati and Memphis are hotter; and Boston and Chicago are a little cooler.

July, the warmest month of the Utah year, has a mean temperature of 71.5—which is far from debilitating. And January, which is the coldest month in Utah, shows an average mean temperature of 26.2—which would not be called trying on even the most delicate constitution.

Taken over a period of five years, the average precipitation for Utah has been somewhat more than 13 inches—rain, snow, sleet and hail. In 1909 the precipitation was 19.31 inches—a record that included obesrvations on desert as well as mountain top. One may fairly challenge the charge that Utah is a part of the "arid belt." To be sure, there were 43 inches at Boston, and 50 inches at Memphis. But the main value of humidity is its effect on outdoor property—the crops. And too much rain is worse than too little. In fact, there is not a level acre in Utah that is not capable of producing profitable crops with the moisture furnished by nature.

Due in large degree to the mild and equable temperature of Utah, the health of the human race is better here than

elsewhere. The average annual death rate from all causes, for the entire United States is 16.5 to the thousand of population. In Utah the annual death rate is 10.8. And it is interesting to observe the predominance of deaths from old age in Utah—33 to the thousand in 1910, and 50 to the thousand in each year since. Man's natural tendency to cling to life is reinforced by superior healthful conditions in Utah. This State has never exploited its advantages to those suffering from pulmonary diseases of the various kinds—commonly grouped under the classification of "lung trouble." But newcomers who have been so afflicted have made report of permanent and often remarkable improvement; and Utah has been made the objective point for many who had lost hope in less hospitable climates. Some have tarried too long in impossible places—and their demise has appreciably increased the total death rate. But the prevalent sunshine, the moderate extremes of temperature, the altitude and the mountain breezes have restored very many to health, and have given lease of life to thousands of others.

Utah's conditions seem especially favorable to health in children. The death rate from diseases peculiar to infants is especially low. And in general, more deaths have been due to accidents than to diphtheria, typhoid fever, bronchopneumonia and meningitis combined. Death never is an inspiriting topic; but it is well to add that the five-year average for homicides in Utah has been but 2.7 to the thousand of population—a record which any eastern state would be proud to duplicate.

These are the basic conditions. In seeking a new place of residence, a man wants to know if the proffered locality is habitable; if the rigors of climate are not forbidding; if the promise of "the early and the later rain" has been kept to that region, and if the airs in daytime and at night are healthful. For his convincing, the above statement has been collated from the Government statistics, so far as weather conditions are concerned, Section Director Alfred H. Thiessen having kindly provided the data; and as to health, the

writer is indebted to Dr. T. B. Beatty, secretary of the state board of health.

After that, comes a variety and a great number of reasons why Utah should be selected as a place of residence. One reason is that, because of the conditions outlined above, men and women are more capable of performing the tasks that life lays upon them. Health and fair weather make them happy. They are more effective in whatever business they undertake. They have more self reliance, more courage. They meet misfortune, if it comes, with a better grace; and they recover more quickly from its effects. They have a keener zest in life, and a more severe demand for excellence in every production. Because of that, Utah schools take gold medals at every great exposition; Utah fruit wins first premiums at fairs, and Utah livestock exhausts the blue ribbons at Portland and at Chicago. Because of that, a more exacting demand is laid on newspapers—and the daily and weekly press of the state is hardly equalled in New England. Because of that, the love of liberty is more deep seated, and patriotism here is a passion, and religion is pure and undefiled.

That may suggest another question from the man seeking a new place of residence in the west. Numerically, the church membership of the Mormons exceeds that of any other denomination. But in every community of size there are sanctuaries of other creeds. And in no case is the slightest hostility shown by members of the dominant faith. At Layton, Utah, a Presbyterian church was constructed twenty years ago. It has stood untenanted for a year at time, its gate locked and its paths grown over with grass. Yet never a pane in one of its windows has been broken. It is doubtful if a Mormon church could fare better in the most amiable community.

In Salt Lake City nearly every denomination has its place of worship, and the men presiding there are singularly able,—men who are listened to with interest and with profit whenever they address audiences of the east. The Catholic

cathedral is an especially imposing structure, beautiful in its interior, and regularly filled with big congregations. The Presbyterians, the Congregationalists, the Methodists, the Baptists, the Episcopalians, the Christians, Scientists, the Adventists, the Jews and even the Greeks have their several places of worship. And that condition obtains throughout the state. Men worship God "according to the dictates of their own consciences" in Utah.

One-fourth of the revenues of the State are devoted to the cause of education. The State University takes high rank among the educational institutions of the country, and its graduates ornament every one of the liberal professions, or prosper in trade. The Utah Agricultural College without question is doing the largest and the most effective work of any school in its class west of the Missouri river. The State Normal School is steadily raising the efficiency of teachers, and Utah teachers are everywhere recognized as especially competent and desirable.

But what can a man do if he selects Utah as a place of residence? What are his opportunities here? Well, to begin where Adam began—with the soil, there are millions of acres of idle land in Utah, ready to repay with profitable crops the labor of the farmer. For the most part it is sagebrush land. Some desirable tracts still await the homesteader. The law allows each citizen who has not yet exhausted his homestead rights 320 acres of land. For the most part it will have to be regarded permanently as dry land, and must be cultivated without the advantage of irrigation. In time the larger portion of the State will be under irrigation ditches; but that alluring prospect must not be expected at once by the homesteader. To perfect title he must cultivate at least one-eighth of his homestead the second year, one-fourth the third year, and one-half the fourth year. The Agricultural College tells him he should farm his land one year, and let it lie fallow the next. But with a tract of such size the farmer may make a crop on half his ground each year alternately. And, while there will be no immediate promise of irrigation, the

settler will still find water within easy digging under his land—sufficient for domestic and livestock uses.

Besides the Government land, and the State land which can be secured on easy terms, there is much ot a desirable nature that awaits the purchaser with a little money—land the title to which has been made by others. And all of it, however secured, is capable of producing, with intelligent cultivation, from ten to twenty bushels of wheat per acre. The Grace Brothers, of Juab county, have done even better than that with every acre of their very large dry-farm holdings; and every year of good farming has brought them increasingly abundant crops. The land is as well adapted to the production of any other crop common to the temperate zone. And the climate is especially favorable to the perfection of fruit culture—humidity and temperature seeming to insure a peculiarly valued flavor, texture and color. Good land can be purchased, if purchase be desired, at from five to twenty dollars an acre in either large or small tracts.

The mines of Utah have been a mighty contributor to the total of the State's productive wealth. Gold, silver, copper, lead, zinc, iron—all invite the developer of mines. And the modern processes of reclaiming the metals has made possible the working of very low-grade ores. For example, the Utah Copper Company is paying most inviting dividends with material that runs less than 2 per cent copper. The smelters of the state have a daily capacity of more than ten thousand tons, and the annual production of the four leading metals in Utah has been nearly $40,000,000.

There is no end of coal and of iron in Utah. The former is being mined and marketed with profit to a number of enterprising companies, and the homes and the factories of the State need not go beyond the borders of Utah for their fuel. The iron still awaits the arrival of that capital which up to the present has so strangely neglected the latent riches of the Utah hills. There is every variety of stone, from granite to gems; and there is natural asphalt enough to pave the transcontinental highway.

These are but the material things. These do not make a state. These are not set forth as answer to the question: Why should a man choose Utah as a place of residence?

> What constitutes a state?
> Not high-raised battlement or labored mound,
> Thick wall, or moated gate;
> Not cities proud with spires and turrets crowned.
> No! Men, high-minded men,
> With powers as far above dull brutes endued
> In forest, brake or den,
> As beasts excel cold rocks and brambles rude—
> Men who their duties know,
> But know their rights, and knowing, dare maintain.

Utah is a good place of residence because of the high character of manhood and the womanhood of the State. It took good human material to face this region, in the first place. It took the qualities of the pilgrims at Plymouth, the founders of the Western Reserve, the builders of commonwealths in the Mississippi Valley to win from a desert the foundation of homes, the warrant for cities. They were absolutely alone. They were cut off by distance and desolation, by dangers and difficulty from the rest of the world. But their achievement proved the worth of their State, and won to their fellowship the company of tens of thousands who found peace and plenty and health and happiness in Utah. Here is culture, and capability. Here is fellowship that is worth while. Here is opportunity for the man who is willing to work. Here is latent wealth awaiting development. Here is an infinitely better chance for the poor man than the poor man had at the beginning—and those beginners, if living, are testimonies to the worth of the region they chose; and if gone to their reward, they have left proof strong as Holy Writ that in Utah worth will win.

Because of a sentiment which all of us recognize, people from the east have been going around and across Utah for lesser chances in the states beyond. The regions to the west and the north and the south have been exploited—and developed. This State is just beginning to arrive at its just